





Mushrooms and Other Fungi

1. *Boletus Satanus*; 2. *Agaricus Muscarius*; 3. *Lycoperdon*; 4. *Morchella Esculenta*;
 5. *Belvella*; 6. *Agaricus Campestris*; 7. *Phallus*; 8. *Agaricus Phalloides*;
 9. *Boletus Edulis*; 10. *Rhizopogon* (*Truffle*)

THE STORY OF THE UNIVERSE

*Told by Great Scientists
and Popular Authors*

COLLECTED AND EDITED

By ESTHER SINGLETON

Author of "Turrets, Towers and Temples," "Wonders of Nature,"
"The World's Great Events," "Famous Paintings," Translator
of Lavignac's "Music Dramas of Richard Wagner"

FULLY ILLUSTRATED



VOLUME III
THE
EARTH'S
GARMENT:
FLORA

THE CURRENT LITERATURE
PUBLISHING CO.,
NEW YORK

COPYRIGHT 1905
P. F. COLLIER & SON

ILLUSTRATIONS

Mushrooms and Fungi	<i>Frontispiece</i>
Familiar Trees	<i>Opposite p. 901</i>
Herbs, Useful and Medicinal	" 949
Flowers, Curious and Beautiful	" 997
Cacti, Rare Flowers, and Fuci	" 1045
Cereals and Food Plants	" 1093
Bacteria and Vegetable Germs	" 1141
Nuts and Fruits	" 1213
Lichens	" 1261

CONTENTS

THE VEGETABLE KINGDOM. David Robertson	859
FLORA OF THE EARLY MESOZOIC. Sir J. William Dawson	871
EXISTING LIFE-FORMS OF PLANTS. Edward Clodd	887
PLANT GEOGRAPHY. Louis Figuier	898
ZONES OF VEGETATION. M. J. Schleiden	930
PHYSIOGNOMY OF PLANTS. Alexander von Humboldt	946
THE GENESIS OF FLOWERS. Alexander S. Wilson	957
LIFE HISTORY OF PLANTS. E. W. Prevost	968
LIFE-FORMS OF PLANTS. Edward Clodd	975
CLASSIFICATION OF PLANTS. Louis Figuier.	984
FRUITS AND SEEDS. Lord Avebury	1002
LEAVES. R. Lloyd Praeger	1016
WIND-FERTILIZED FLOWERS. Alexander S. Wilson	1027
MOVEMENTS OF PLANTS. David Robertson	1037
MOVEMENT IN PLANTS. Charles Darwin	1045
FLOWER COLORATION. Alexander S. Wilson	1061
QUEER FLOWERS. Grant Allen	1068
ATHENA IN THE EARTH. John Ruskin	1077
PROGRESS OF CULTIVATION. Alphonse de Candolle	1091
VEGETABLE MIMICRY AND HOMOMORPHISM. Alexander S. Wilson	1099
THE BAMBOO AND PLANT GROWTH. R. Camper Day	1114
THE REIGN OF EVERGREENS. Grant Allen	1125
OUR MICROSCOPIC FOES. A. Winkelried Williams	1131
FOREST FORMATIONS. M. J. Schleiden	1135

THE HIGH WOODS. Charles Kingsley	1146
MILK-SAP PLANTS. M. J. Schleiden	1161
NUTS. Grant Allen	1174
THE CACTUS TRIBE. M. J. Schleiden	1180
FUNGI. Hugh Macmillan	1189
FAIRY RINGS. A. B. Steele	1204
LICHENS. Hugh Macmillan	1208
MOSSES. Hugh Macmillan	1220
EUROPEAN SEA-WEEDS. P. Martin Duncan	1230
SARGASSUM. Cuthbert Collingwood	1263
GLOSSARY OF BOTANICAL TERMS	1269

THE STORY OF THE UNIVERSE

(VOLUME THREE)

THE STORY OF THE UNIVERSE

THE VEGETABLE KING- DOM. — DAVID ROBERTSON

THERE is perhaps scarcely any science that can be more within the reach of the means of the humblest student than the science of botany. A pocket lens, a sharp penknife, and a book descriptive of the flora of the district or country where one lives will form a sufficient equipment to enable the student to name and classify whatever plants he may meet with in his rambles in search of them.

It is by no means intended to imply that finding out the names of plants and being able to classify them constitute the whole science of botany. The truth is that many of the problems in connection with classification are most abstruse, so much so that even now the most recent and generally received system of classification can only be considered provisional. This is especially the case in regard to the lower forms of vegetable life. The life-history of many of the most minute and lowly plants is but imperfectly known, owing to their extreme minuteness and the different forms which they assume at the various stages of their life-history.

This, however, does not detract from the pleasure

which any one may derive from being able to describe and name any flowering plants which are to be found in any country at certain seasons.

The dependence of mankind on plants is too obvious to require mention.

To a large extent the vegetation of a district determines its character; for without plants no landscape would possess any particular attractiveness, and every one knows the depressing effect produced by a barren, treeless waste. The contrast between this and fields rich in pasture has occurred to every one; and a well-wooded country never fails to please the eye of the observer.

Mighty forests, teeming with life, have a powerful influence on the imagination; and the value of forests both as regards their effect on climate and their economic importance has been so thoroughly recognized that in the case of India stringent measures have been adopted for their preservation.

Some knowledge of plant life also enables one to guard against the evil and often fatal effects produced by eating poisonous fruits and poisonous fungi.

Some of the lowly organized flowerless plants are man's most deadly and insidious enemies. These from their excessive minuteness are quite invisible to the naked eye.

Before proceeding further, it will be necessary to give a brief account of the different parts which go to compose the complete flowering plant. The reader who desires a full and detailed account of the different organs of the flowering and flowerless

plants will find this in any standard text-book of botany.

We will take any full-grown flowering plant and begin with the root.

The root may be called the descending portion of the axis.

The ascending portion of the axis is usually supplied with leaves, flowers, and green coloring matter, whereas the root is usually devoid of these.

The root generally penetrates into the soil and fulfils a double function.

It is by means of the roots that the plant is attached to the earth and prevented from being blown about by the winds.

In the case of large forest trees, the far-spreading roots have an immense power of resistance. The large surface of a giant tree in full leaf has to endure an enormous lateral pressure during a high wind, and even hurricanes may fail to uproot a large tree, which they may snap asunder. Not only does the root by penetrating the soil attach the plant to the earth, but it absorbs nourishment from the soil for the support of the plant. The root, therefore, fulfils a double function.

The root is at first furnished with a conical hood of cellular tissue, *i. e.*, tissue consisting entirely of cells or little closed bags made up of an outside wall and contents.

The root cup is well seen in some kinds of water-plants, such as duckweed.

There are plants whose roots do not descend. Certain plants hang from the branches of trees, and

though they have roots these roots never penetrate the soil. Plants of this kind are called Epiphytes (Greek *epi*, upon, and *phyton*, plant). Aerial orchids, which grow in warm and moist parts of India and other countries, are attached to branches of trees or other kinds of support, and their roots hang down from the peculiar stems and are very soft and delicate at the tips.

It must be borne in mind that there is no absolute distinction between root and stem; for some trees have roots which form lateral buds, viz., *Pyrus japonica*, *Maclura aurantiaca*, and many others.

This is quite in accordance with the fact that in the organic world different organs frequently shade into one another.

The true root of the plant in its earliest state of existence, that is, as it exists in the seed prior to germination, is the downward prolongation of the axis.

In the case of the division of flowering plants called Monocotyledons (Greek *monos*, single, and *kotyledon*, seed-leaf), and in such so-called flowerless plants as ferns, the lower end of the axis soon ceases to grow and the roots which supply these plants with nourishment are really lateral growths. The roots of plants are variously named. Sometimes the branches of the roots are small, and the central axis thick and of considerable length. This kind of root is named a tap-root, and may be well seen in the carrot.

In the turnip, beet, and other plants, where this organ is developed in such a manner as to serve as a reservoir of nutriment, the root is tuberous.

Many roots are fibrous; this may be well seen in grasses.

The perennial woody forms of fibrous roots are very characteristic of shrubby Dicotyledons (plants with two seed-leaves).

Leaves are of two kinds, namely, foliage-leaves and flower-leaves.

A leaf is generally a broad, flat, horizontal surface. It is usually thin, and can be divided by a perpendicular plane, the median plane, into two similar halves.

When the leaves are what is called symmetrical, the parts into which they are divided are counterparts.

If one of these parts were held in front of a looking-glass, the reflected image of this part would represent the part from which it had been separated.

Many leaves, however, can not thus be divided. When this is the case they are said to be unsymmetrical.

The tropical plant begonia affords an excellent example of an unsymmetrical leaf.

The leaves of the spruce are not flat but needle-shaped.

In rushes and many species of stone-crops the leaves are cylindrical or round.

The leaf consists of three parts, viz., the sheath, the stalk or petiole, and the lamina or blade. The sheath incloses the stem at the insertion of the leaf, and has a tubular or sheath-like form. It is well seen in grasses and such plants as celery, corn, parsnip, carrot, and other plants belonging to the *Umbelliferae*

[Lat. *umbella* (*umbra*, shade), little shade, and *ferre*, to bear].

The leaf-stalk is narrow, and has a semi-cylindrical or prismatic form, bearing at its end the expanded leaf.

When the stalk is flattened and resembles a leaf, as in the case of the Australian acacias, it is termed a phyllode (Greek *phyllon*, a leaf, and *eidōs*, form).

Many leaves have no sheath, but only the stalk and the blade. This is the case in the maple and gourd.

The leaves of the grasses have no stalk, but only sheath and blade.

The blade is often the only part present, as in the tobacco plant and tiger-lily. Small appendages, looked upon as belonging to the sheath, are frequently present, and are termed stipules (from Lat. *stipula*, blade). Leaves having these appendages are called stipulate, and leaves devoid of them are exstipulate (from Lat. *ex*, privative, without, and *stipula*, blade).

A few plants, such as grasses, have a small outgrowth from the inner upper surface of the leaf at the part where the sheath and the blade are joined. This outgrowth is named a ligule (from Lat. *ligula*, a little tongue).

If a leaf is carefully examined it will be found that the internal tissues differ in character. The fundamental tissue is generally green, and is named the mesophyll (Greek, *mesos*, or *messos*, middle, and *phyllon*, leaf).

It will be seen that bands run through the fundamental tissue called the veins of the leaf. These

veins consist of what are termed fibro-vascular bundles. They endure longer than the fundamental tissue, and may frequently be seen after the leaf is withered and dead, forming the skeleton of the leaf.

The arrangement of the veins or fibro-vascular bundles is characteristic of large groups of plants.

In the narrow linear leaves of grasses the stronger veins run almost parallel. In broad leaves, such as those of the lily-of-the-valley, the veins curve, but do not form a network of tracery as in oaks and other Dicotyledons. The margin of leaves is frequently divided, but the technical terms used in describing such leaves can be found in any text-book of botany. They may either be simple or compound. A simple leaf consists of a single lamina, however much it may be divided, provided the divisions do not extend to the central vein or mid-rib. A leaf is compound when, besides the principal leaf-stalks, a number of lateral leaf-stalks exist bearing at their ends laminae. The leaves of many plants are compound. The sensitive plant (*Mimosa pudica*) furnishes an excellent example of the compound leaf.

The characteristic color of foliage leaves is green, and they are so arranged as to receive as much sunlight as possible. The importance of the plant receiving a good supply of light will be referred to when treating of the growth of plants. It is as true of plants as of animals that the organs most suitable for their surroundings are so arranged as to be most advantageous to the individual. Had leaves been placed vertically they would only have received dif-

fused sunlight instead of the direct rays of the sun. No vegetable life could exist but for the sun, as plants not only require light but heat as well.

When the foliage leaves are small they are very numerous, as may be seen in conifers; and when these leaves are large they are not nearly so numerous as, for example, in the sunflower.

Sometimes leaves may consist of scales. These scales are always found on stems growing underground, as in the onion; but they sometimes occur on stems growing above-ground.

Such plants as *Orobanche* and *Neottia* have no other kind of leaves except scales.

The leaves are developed very near the apex of the growing stem.

The portions of the stem which lie between the leaves are termed the internodes, and the parts where the leaves are inserted are termed the nodes.

Leaves are arranged in various ways, intimately connected with the order of their development. They may be developed so that three or more are at the same level on the stem; this arrangement is termed a *whorl*. Or they may be developed singly; this arrangement is termed *scattered*. For a full account of the various leaf-arrangements any text-book on botany may be consulted.

We have here merely referred to some of the more obvious arrangements of the leaves.

Certain leaves possess a remarkably abnormal shape; for example, stone-crops have cylindrical leaves; if the leaf of an agave is cut across, the section is triangular; leeks, again, are tube-shaped; the

central cavity being due to the rapid growth of the outer tissue. These leaves are all juicy or succulent; certain other leaves are leathery, that is, they have a harder and thicker epidermis than the succulent leaves, and may last for several years, as, for example, in the holly and box.

Spines and tendrils are modifications of leaves, or parts of leaves. The tendrils are formed out of entire leaves, mid-ribs, leaflets, or stipules. Both spines and tendrils, however, may be modified branches of the stem.

In buds the leaves are packed or folded in various ways. This is best seen before the buds are opened in spring. The buds may then be pulled carefully to pieces, and in this way the manner in which the leaves are folded can be studied.

We now come to the flower.

Flowers consist of leaves modified in different ways.

Take, for example, the flower of the orange. The flower will be seen to be borne on a short branch which serves as the stalk, and is distinguished by the name of peduncle (from Lat. *pedunculus*, little stalk). It will be seen that there are no internodes between the flower-leaves.

The lowest and outermost part of the flower forms a little cup having upon its margin fine small teeth, indicating the number of leaves which are joined together so as to form the cup or calyx.

These leaves are named (from Lat. *calyx*, a covering; Greek *kalyx*, from *kalyptein*, to cover) the calyx-leaves, or sepals (French *sépale*). Although they

are united in the flower of the orange, they are often separate in other plants.

In the sacred Lotus or Padma or Pudma of India the sepals are separate or free. The leaves immediately inside the calyx are usually five in number. They are erect, or only slightly curved, and do not grow together like the leaves of the calyx. They are white and wax-like. These leaves form together what is termed the corolla, and the separate leaves of the corolla (from Lat. *corolla*, a little wreath) are termed petals (from Greek *petalon*, leaf). In the case of the orange the petals fall early away.

If the calyx and petals are carefully removed, the next part of the flower can be observed.

This series of flower-leaves differs very much in structure from both sepals and petals. Each leaf of this series consists of a linear stalk-like portion, bearing an upper somewhat long and grooved head. The stalk is named the filament, and the oblong head is named the anther (Greek *anthos*, a flower). The stalk and the head together form what is called the stamen (Lat. *stamen*, [Greek *histanai*, to stand] fibre; literally, the warp in the upright loom of the ancients). The stamens of the orange are rather shorter than the petals, and are united to each other.

When the anther is mature, each of its grooves splits near the edge, and allows the fine powdery granules which fill the anthers to be removed by insects or by other means. This fine powder is named the pollen, and each of the granules composing it is named a pollen grain. If the stamens are now removed the centre of the flower alone is left.

If the lower part of the centre of the flower be cut across, it will be found to be divided into a large number of cavities containing the minute rudiments of future seeds. It will be seen that there are ten cavities, though they may vary in number. The central organ of the flower is named the pistil (from Lat. *pistillum*, pestle). The pistil is usually composed of united leaves.

The separate leaves of the pistil are termed carpels (from Greek *karpōs*, fruit). These leaves are sometimes not combined, as they are in the orange. The style belongs to the carpel, and varies considerably in length, as well as in stoutness, in different flowers. Although the carpels may be united, the styles may remain completely separate, as, for example, in the pink, or, as in the fuchsia, they may be combined into a single rod.

The pollen grains (Lat. fine flour) contained in the anther are composed of very rich protoplasm (Greek *protos*, first; *plasma*, formative matter), which usually has in it small drops of oil and small starch granules. The pollen grains are bounded by two principal layers, an outer and an inner; the purpose of the outer layer (which is often provided with thickenings in the shape of knots, spines, etc.) being to preserve the contents of the grain from evaporation.

The inner layer is living and capable of growth, and at certain spots it possesses thickenings which project into the protoplasm. Opposite to these the external cuticle is frequently thinner, and this eventually is lifted off as a sort of lid, and through this the

inner substance can grow out, and is then named the pollen tube.

When the anther lobes open to discharge their pollen grains, these grains are completely developed.

The grains fall on the part of the ovary named the stigma (Greek *stigma*, a puncture made with a sharp instrument; here it means a sharp point or apex) and the inner layer begins to force its way out. The tube is produced from the contents of the pollen grain, and is formed by growth, just as any other part of the plant. The pollen tube passes down to the ovules, the route depending on the length of the style. The time taken by the pollen tube to reach the ovary may amount to a few hours in certain plants, while it needs months in others. It is necessary that at least one pollen tube should enter the mouth of the ovule before it can develop into a seed. The seed, when mature, contains the embryo plant.

It is not possible for an ovule in numerous cases to be fertilized by pollen from stamens that grow near it in the same flower.

It not unfrequently happens that a flower possesses stamens and no pistil, or a pistil and no stamens. Flowers of this kind are technically termed diœcious (Greek *dis*, twice, and *oikia* or *oikos*, place of abode), if the male and female flowers are on different plants. The flowers of such plants as oaks and birches are male and female, but are borne on the same plant, hence termed monœcious (Greek *monos*, single). The flowers that contain stamens only are called male flowers, and those containing pistils only are named female flowers.

The oaks and birches, as has been stated, have both the male and female flowers on the same plant, though in other cases the male flower is borne on one plant and the female flower on another.

In cases like these the wind carries the pollen from one plant to another. In wind-fertilized flowers the flower is usually produced prior to the foliage leaves, or at least before the plant is crowded with leaves.

These plants produce an immense amount of pollen.

Besides the transference of pollen by the agency of the wind, insect agency plays a very important part. These insect-fertilized plants are much more conspicuous than those fertilized by the wind.

There are numerous natural contrivances in plants to prevent self-fertilization, as this process of self-fertilization is far less effective in producing seeds than when the ovules are fertilized by pollen from another plant of the same species.

In some plants the stigma is mature before the anther, and in such a case the pollen must be brought from a flower that has bloomed a little earlier than itself.

FLORA OF THE EARLY MESOZOIC. — SIR J. WILLIAM DAWSON

GREAT physical changes occurred at the close of the Carboniferous age. The thick beds of sediment that had been accumulating in long lines along the primitive continents had weighed down the earth's crust. Slow subsidence had been proceed-

ing from this cause in the coal-formation period, and at its close vast wrinklins occurred, only surpassed by those of the old Laurentian time. Hence in the Appalachian region of America we have the Carboniferous beds thrown into abrupt folds, their shales converted into hard slates, their sandstones into quartzite and their coals into anthracite, and all this before the deposition of the Triassic Red Sandstones which constitute the earliest deposit of the great succeeding Mesozoic period. In like manner the coal-fields of Wales and elsewhere in western Europe have suffered similar treatment, and apparently at the same time.

This folding is, however, on both sides of the Atlantic limited to a band on the margin of the continents, and to certain interior lines of pressure, while in the middle, as in Ohio and Illinois in America, and in the great interior plains of Europe, the coal-beds are undisturbed and unaltered. In connection with this we have an entire change in the physical character of the deposits, a great elevation of the borders of the continents, and probably a considerable deepening of the seas, leading to the establishment of general geographical conditions which still remain, though they have been temporarily modified by subsequent subsidences and re-elevations.

Along with this a great change was in progress in vegetable and animal life. The flora and fauna of the Palæozoic gradually die out in the Permian and are replaced in the succeeding Trias by those of the Mesozoic time. Throughout the Permian, however, the remains of the coal-formation flora

continue to exist, and some forms, as the *Calamites*, even seem to gain in importance, as do also certain types of coniferous trees. The Triassic, as well as the Permian, was marked by physical disturbances, more especially by great volcanic eruptions discharging vast beds and dikes of lava, and layers of volcanic ash and agglomerate. This was the case more especially along the margins of the Atlantic, and probably also on those of the Pacific. The volcanic sheets and dikes associated with the Red Sandstones of Nova Scotia, Connecticut, and New Jersey are evidences of this.

At the close of the Permian and beginning of the Trias, in the midst of this transition time of physical disturbance, appear the great reptilian forms characteristic of the age of reptiles, and the earliest precursors of the mammals, and at this time the old Carboniferous forms of plants finally pass away, to be replaced by a flora scarcely more advanced, though different, and consisting of pines, cycads, and ferns, with gigantic equisetæ, which are the successors of the genus *Calamites*, a genus which still survives in the early Trias. Of these groups the conifers, the ferns, and the equisetæ are already familiar to us, and, in so far as they are concerned, a botanist who had studied the flora of the Carboniferous would have found himself at home in the succeeding period. The cycads are a new introduction. The whole, however, come within the limits of the cryptogams and the gymnosperms, so that here we have no advance.

As we ascend, however, in the Mesozoic, we find

new and higher types. Even within the Jurassic epoch, the next in succession to the Trias, there are clear indications of the presence of the endogens, in species allied to the screw-pines and grasses; and the palms appear a little later, while a few exogenous trees have left their remains in the Lower Cretaceous, and in the Middle and Upper Cretaceous these higher plants come in abundantly and in generic forms still extant, so that the dawn of the modern flora belongs to the Middle and Upper Cretaceous. It will thus be convenient to confine ourselves in this chapter to the flora of the earlier Mesozoic.

Passing over for the present the cryptogamous plants already familiar in older deposits, we may notice the new features of gymnospermous and phænogamous life, as they present themselves in this earlier part of the great reptilian age, and as they extended themselves with remarkable uniformity in this period over all parts of the world. For it is a remarkable fact that, if we place together in our collections fossil plants of this period from Australia, India, China, Siberia, Europe, or even from Greenland, we find wonderfully little difference in their aspect. This uniformity prevailed in the Palæozoic flora; and it is perhaps equally marked in that of the Mesozoic. Still we must bear in mind that some of the plants of these periods, as the ferns and pines, for example, are still world-wide in their distribution; but this does not apply to others, more especially the cycads.

The cycads constitute a singular and exceptional type in the modern world, and are limited at present

to the warmer climates, though very generally distributed in these, as they occur in Africa, India, Japan, Australia, Mexico, Florida, and the West Indies. In the Mesozoic age, however, they were world-wide in their distribution, and are found as far north as Greenland, though most of the species found in the Cretaceous of that country are of small size, and may have been of low growth, so that they may have been protected by the snows of winter. The cycads have usually simple or unbranching stems, pinnate leaves borne in a crown at top, and fruits which, though somewhat various in structure and arrangement, are all of the simpler form of gymnospermous type. The stems are exogenous in structure, but with slender wood and thick bark, and barred tissue, or properly as tissue intermediate between this and the disk-bearing fibres of the pines.

The greater part of the cycads of the Mesozoic age would seem to have had short stems and to have constituted the undergrowth of woods in which conifers attained to greater height. An interesting case of this is the celebrated dirt-bed of the quarries of the Isle of Portland, long ago described by Dean Buckland. In this fossil soil trunks of pines, which must have attained to great height, are interspersed with the short, thick stems of cycads, of the genus named *Cycadoidea* by Buckland, and which from their appearance are called "fossil birds' nests" by the quarrymen. Some, however, must have attained a considerable height so as to resemble palms.

The cycads, with their simple, thick trunks,

usually marked with rhombic scars, and bearing broad spreading crowns of large, elegantly formed pinnate leaves, must have formed a prominent part of the vegetation of the Northern Hemisphere during the whole of the Mesozoic period. A botanist, had there been such a person at the time, would have found this to be the case everywhere from the equator to Spitzbergen, and probably in the Southern Hemisphere as well, and this throughout all the long periods from the Early Trias to the Middle Cretaceous. In a paper published in the *Linnæan Transactions* for 1868, Dr. Carruthers enumerates twenty species of British Mesozoic cycads, and the number might now be considerably increased.

The pines present some features of interest. In the Mesozoic we have great numbers of beautiful trees, with those elegant fan-shaped leaves characteristic of but one living species, the *Salisburia*. or ginkgo-tree of China. It is curious that this tree, though now limited to eastern Asia, will grow, though it rarely fruits, in most parts of temperate Europe, and in America as far north as Montreal, and that in the Mesozoic period it occupied all these regions, and even Siberia and Greenland, and with many and diversified species.

Salisburia belongs to the yews, but an equally curious fact applies to the cypresses. The genus *Sequoia*, limited at present to two species, both Californian, and one of them the so-called "big tree," celebrated for the gigantic size to which it attains, is represented by species found as far back at least as the Lower Cretaceous, and in every part of the

Northern Hemisphere.* It seems to have thriven in all these regions throughout the Mesozoic and early Kainozoic, and then to have disappeared, leaving only a small remnant to represent it in modern days. A number of species have been described from the Mesozoic and Tertiary, all of them closely related to those now existing.

The name itself deserves consideration. It is that of an Indian of the Cherokee tribe, Sequo Yah, who invented an alphabet without any aid from the outside world of culture, and taught it to his tribe by writing it upon leaves. This came into general use among the Cherokees before the white man had any knowledge of it; and afterward, in 1828, a periodical was published in this character by the missionaries. Sequo Yah was banished from his home in Alabama, with the rest of his tribe, and settled in New Mexico, where he died in 1843.

When Endlicher was preparing his synopsis of the conifers, in 1846, and had established a number of new genera, Dr. Jacob Tschudi, then living with Endlicher, brought before his notice this remarkable man, and asked him to dedicate this red-wooded tree to the memory of a literary genius so conspicuous among the red men of America. Endlicher consented to do so, and only endeavored to make the name pronounceable by changing two of its letters.

Endlicher founded the genus on the redwood of the Americans, *Taxodium sempervirens* of Lamb; and named the species *Sequoia sempervirens*. These

* In the Eocene of Australia.

trees form large forests in California, which extend along the coast as far as Oregon. Trees are there met with of 300 feet in height and 20 feet in diameter. The seeds were brought to Europe a number of years ago, and we already see in upper Italy and around the Lake of Geneva, and in England, high trees; but, on the other hand, they have not proved successful around Zurich.

In 1852, a second species of *Sequoia* was discovered in California, which, under the name of big tree, soon attained a considerable celebrity. Lindley described it, in 1853, as *Wellingtonia gigantea*; and, in the following year, Decaisne and Torrey proved that it belonged to *Sequoia*, and that it accordingly should be called *Sequoia gigantea*.

While the *Sequoia sempervirens*, in spite of the destructiveness of the American lumbermen, still forms large forests along the coasts, the *Sequoia gigantea* is confined to the isolated clumps which are met with inland at a height of 5,000 to 7,000 feet above sea-level, and are much sought after by tourists as one of the wonders of the country. Reports came to Europe concerning the largest of them which were quite fabulous, but we have received accurate accounts of them from Professor Whitney. The tallest tree measured by him has a height of 325 feet, and in the case of one of the trees the number of the rings of growth indicated an age of about 1,300 years. It had a girth of 50 to 60 feet.

We know only two living species of *Sequoia*, both of which are confined to California. The one (*S. sempervirens*) is clothed with erect leaves, arranged

in two rows, very much like our yew-tree, and bears small, round cones; the other (*S. gigantea*) has smaller leaves, set closely against the branches, giving the tree more the appearance of the cypress. The cones are egg-shaped, and much larger. These two types are, therefore, sharply defined.

Both of these trees have an interesting history. If we go back into the Tertiary, this same genus meets us with a long array of species. Two of these species correspond to those living at present: the *S. Langsdorffii* to the *S. sempervirens*, and the *S. Couttsiae* to the *S. gigantea*. But, while the living species are confined to California, in the Tertiary they are spread over several quarters of the globe.

Let us first consider the *Sequoia Langsdorffii*. This was first discovered in the lignite of Wetterau, and was described as *Taxites Langsdorffii*. Heer found it in the upper Rhone district, and there lay beside the twigs the remains of a cone, which showed that the *Taxites Langsdorffii* of Brongniart belonged to the Californian genus *Sequoia* established by Endlicher. He afterward found much better preserved cones, together with seeds, along with the plants of east Greenland, which fully confirmed the determination. At Atanekrdluk in Greenland (about 70° north latitude) this tree is very common. The leaves, and also the flowers and numerous cones, leave no doubt that it stands very near to the modern redwood. It differs from it, however, in having a much larger number of scales in the cone. The tree is also found in Spitzbergen at nearly 78° north latitude, where Nordenskiöld has collected, at Cape

Lyell, wonderfully preserved branches. From this high latitude the species can be followed down through the whole of Europe as far as the middle of Italy (at Senegaglia, Gulf of Spezia). In Asia, also, we can follow it to the steppes of Kirghisen, to Possiet, and to the coast of the sea of Japan, and across to Alaska and Sitka. It is recognized by Mr. Starkie Gardner as one of the species found in the Eocene of Mull in the Hebrides. It is thus known in Europe, Asia, and America from 43° to 78° north latitude, while its most nearly related living species, perhaps even descended from it, is now confined to California.

With this *S. Langsdorfi*, three other Tertiary species are nearly related (*S. brevifolia*, Hr., *S. disticha*, Hr., and *S. Nordenskiöldi*, Hr.). These have been met with in Greenland and Spitzbergen and one of them has been found in the United States. Three other species, in addition to these, have been described by Lesquereux, which appear to belong to the group of the *S. Langsdorfi*, viz., *S. longifolia*, Lesq., *S. angustifolia*, and *S. acuminata*, Lesq. Several species also occur in the Cretaceous and Eocene of Canada.

These species thus answer to the living *Sequoia sempervirens*; but we can also point to Tertiary representatives of the *S. gigantea*. Their leaves are stiff and sharp-pointed, are thinly set round the branches, and lie forward in the same way: the egg-shaped cones are in some cases similar.

There are, however, in the early Tertiary six species, which fill up the gap between *S. semper-*

virens and *S. gigantea*. They are the *S. Couttsiæ*, *S. affinis*, Lesq., *S. imbricata*, Hr., *S. sibirica*, Hr., *S. Heerii*, Lesq., and *S. biformis*, Lesq. Of these, *S. Couttsiæ*, Hr., is the most common and most important species. It has short leaves, lying along the branch, like *S. gigantea*, and small, round cones, like *S. Langsdorfi* and *sempervirens*. Bovey Tracey in Devonshire has afforded splendid specimens of cones, seeds, and twigs, which have been described in the *Philosophical Transactions*. More lately, Count Saporta has described specimens of cones and twigs from Armissan. Specimens of this species have also been found in the older Tertiary of Greenland, so that it must have had a wide range. It is very like to the American *S. affinis*, Lesq.

In the Tertiary there have been found fourteen well-marked species, which thus include representatives of the two living types, *S. sempervirens* and *S. gigantea*.

We can follow this genus still further back. If we go back to the Cretaceous age, we find ten species, of which five occur in the Urgon of the Lower Cretaceous, two in the Middle, and three in the Upper Cretaceous. Among these, the Lower Cretaceous exhibits the two types of the *Sequoia sempervirens* and *S. gigantea*. To the former the *S. Smithiana* answers, and to the latter, the *Reichenbachii*, Gein. The *S. Smithiana* stands indeed uncommonly near the *S. Langsdorfi*, both in the appearance of the leaves on the twigs and in the shape of the cones. These are, however, smaller, and the leaves do not become narrower toward the base. The *S. pectina*,

Hr., of the Upper Cretaceous, has its leaves arranged in two rows, and presents a similar appearance. The *S. Reichenbachii* is a type more distinct from those now living and those in the Tertiary. It has indeed stiff, pointed leaves, lying forward, but they are arcuate, and the cones are smaller. This tree has been known for a long time, and it serves in the Cretaceous as a guiding star, which we can follow from the Urgonian of the Lower Cretaceous up to the Cenomanian. It is known in France, Belgium, Bohemia, Saxony, Greenland, and Spitzbergen (also in Canada and the United States). It has been placed in another genus—*Geinitzia*—but we can recognize, by the help of the cones, that it belongs to *Sequoia*.

Below this, there is found in Greenland a nearly related species, the *S. ambigua*, Hr., of which the leaves are shorter and broader, and the cones round and somewhat smaller.

The connecting link between *S. Smithiana* and *Reichenbachii* is formed by *S. subulata*, Hr., and *S. rigida*, Hr., and three species (*S. gracilis*, Hr., *S. fastigiata* and *S. Gardneriana*, Carr.), with leaves lying closely along the branch, and which come very near to the Tertiary species *S. Couttsiæ*. We have, therefore, in the Cretaceous quite an array of species, which fill up the gap between the *S. sempervirens* and *gigantea*, and show us that the genus *Sequoia* had already attained a great development in the Cretaceous. This was still greater in the Tertiary, in which it also reached its maximum of geographical distribution. Into the present world the two extremes of the genus have alone continued; the

numerous species forming its main body have fallen out in the Tertiary.

If we look still further back, we find in the Jura a great number of conifers, and, among them, we meet in the genus *Pinus* with a type which is highly developed, and which still survives; but for *Sequoia* we have till now looked in vain, so that for the present we can not place the rise of the genus lower than the Urgonian of the Cretaceous, however remarkable we may think it that in that period it should have developed into so many species; and it is still more surprising that two species already make their appearance which approach so near to the living *Sequoia sempervirens* and *S. gigantea*.

Altogether, we have become acquainted, up to the present time, with twenty-six species of *Sequoia*. Fourteen of these species are found in the Arctic zone, and have been described and figured in the *Fossil Flora of the Arctic Regions*. *Sequoia* has been recognized by Ettingshausen even in Australia, but there in the Eocene.

This is, perhaps, the most remarkable record in the whole history of vegetation. The *Sequoias* are the giants of the conifers, the grandest representatives of the family; and the fact that, after spreading over the whole Northern Hemisphere and attaining to more than twenty specific forms, their decaying remnant should now be confined to one limited region in western America* and to two species con-

* The writer has shown that much of the material of the great lignite beds of the Canadian Northwest consists of wood of *Sequoia* of both the modern types.

stitutes a sad memento of departed greatness. The small remnant of *S. gigantea* still, however, towers above all competitors as eminently the "big trees"; but, had they and the allied species failed to escape the Tertiary continental submergences and the disasters of the glacial period, this grand genus would have been to us an extinct type. In like manner the survival of the single ginkgo of eastern Asia alone enables us to understand that great series of taxine trees with fern-like leaves of which it is the sole representative.

Besides these peculiar and now rare forms, we have in the Mesozoic many others related closely to existing yews, cypresses, pines, and spruces, so that the conifers were probably in greater abundance and variety than they are at this day.

In this period also we find the earliest representatives of the endogenous plants. It is true that some plants found in the coal-formation have been doubtfully referred to these, but the earliest certain examples would seem to be some bamboo-like and screw-pine-like plants occurring in the Jurassic rocks. Some of these are, it is true, doubtful forms, but of others there seems to be no question. The modern *Pandanus* or screw-pine of the tropical regions, which is not a pine, however, but a humble relation of the palms, is a stiffly branching tree, of a candelabra-like form, and with tufts of long leaves on its branches, and nuts or great hard berries for fruit, borne sometimes in larger masses, and so protected as to admit of their drifting uninjured on the sea. The stems are supported by masses of aerial

roots like those which strengthen the stems of tree-ferns. These structures and habits of growth fit the *Pandanus* for its especial habitat on the shores of tropical islands, where its masses of nuts are drifted by the winds and currents, and on whose shores it can establish itself by the aid of its aerial roots.

Some plants referred to the cycads have proved veritable botanical puzzles. One of these, the *Williamsonia gigas* of the English oölite, originally discovered by my friend, Dr. Williamson, and named by him *Zamia gigas*, a very tall and beautiful species, found in rocks of this age in various parts of Europe, has been claimed by Saporta for the Endogens, as a plant allied to *Pandanus*. Some other botanists have supposed the flowers and fruits to be parasites on other plants, like the modern *Rafflesia* of Sumatra, but it is possible that after all it may prove to have been an aberrant cycad.

The tree-palms are not found earlier than the Middle Cretaceous. In like manner, though a few Angiosperms occur in rocks believed to be Lower or Lower Middle Cretaceous in Greenland and the Northwest Territory of Canada, and in Virginia, these are merely precursors of those of the Upper Cretaceous, and are not sufficient to redeem the earlier Cretaceous from being a period of pines and cycads.

On the whole, this early Mesozoic flora, so far as known to us, has a monotonous and mean appearance. It no doubt formed vast forests of tall pines, perhaps resembling the giant Sequoias of California; but they must for the most part have been dark and dismal woods, probably tenanted by few forms of

life, for the great reptiles of this age must have preferred the open and sunny coasts, and many of them dwelt in the waters. Still we must not be too sure of this. The berries and nuts of the numerous yews and cycads were capable of affording much food. We know that in this age there were many great herbivorous reptiles, like *Iguanodon* and *Hadrosaurus*, some of them fitted by their structure to feed upon the leaves and fruits of trees. There were also several kinds of small herbivorous mammals, and much insect life, and it is likely that few of the inhabitants of the Mesozoic woods have been preserved as fossils. We may yet have much to learn of the inhabitants of these forests of ferns, cycads, and pines. We must not forget in this connection that in the present day there are large islands, like New Zealand, destitute of mammalia, and having a flora comparable with that of the Mesozoic in the Northern Hemisphere, though more varied. We have also the remarkable example of Australia, with a much richer flora than that of the early Mesozoic, yet inhabited only by non-placental mammals, like those of the Mesozoic.

The principal legacy that the Mesozoic woods have handed down to our time is in some beds of coal, locally important, but of far less extent than those of the Carboniferous period. Still, in America, the Richmond coal-field in Virginia is of this age, and so are the anthracite beds of the Queen Charlotte Islands, on the west coast of Canada, and the coal of Brora in Sutherlandshire. Valuable beds of coal, probably of this age, also exist in China,

India, and South Africa; and jet, which is so extensively used for ornament, is principally derived from the carbonized remains of the old Mesozoic pines.

EXISTING LIFE-FORMS OF PLANTS.—EDWARD CLODD

PLANTS are divided into two main groups or sub-kingdoms: I, *Cryptogams* (Greek *Kruptos*, hidden; *gamos*, marriage), or flowerless; II, *Phanerogams* (Greek *phaneros*, open; *gamos*, marriage), or flowering.

I. The *Cryptogams* comprise as their leading representatives: 1. Algæ, Fungi, Lichens; 2. Liverworts, Mosses; 3. Ferns, Horsetails, Clubmosses.

The feature common to these is the absence of any conspicuous organs; *i. e.*, true flowers with stamens and pistils for the production of seeds or fruits. The simplest or single-celled plants increase by subdivision, each cell carrying on an independent life and repeating the process of division. But sexuality is manifest in plants very low down in the scale, the mode of reproduction varying a good deal in different species. In some cryptogams it is almost as complex as in the flowering plants, but notwithstanding the different kinds of sexual organs, there is this fundamental resemblance between them, that the union of the contents of two cells, a male or sperm-cell, and a female or germ-cell, each of which is by itself incapable of further development, is essential to the production of the embryo or seed.

The lowest cryptogams have no stems, leaves, or roots. They are congregations of simple fibreless cells united in rows, or gathered round one another, spreading on all sides. At the bottom of the scale of plant life are the *Algæ*, comprising some 10,000 species, from the minute fresh-water desmids, one-millionth of an inch in length, with their whiplike cilia, the two-hundredth millionth of an inch long, to the giant sea-weeds or tangles, hundreds of feet in length, that cover thousands of square miles of ocean. The green scum of stagnant ponds; the waving filaments in streams; the shell-coated microscopic diatoms that people the ocean, tingeing its depths with olive green, nourishing the whales that play therein, and whose skeletons form deposits hundreds of miles in length; the rose and purple weeds that flourish in shallow seas, and are cast upon their shores, are all members of a group which is perhaps the venerablest of living things. For although their generally fragile forms have been fatal to their preservation as fossils, there is little doubt that the *algæ* flourished in dense masses in primeval oceans, and were the chief, if not the sole, representatives of plant-life on the earth during millions of centuries. Like the foraminifera and other low animal organisms, they illustrate the persistency of the earlier forms, in virtue of their simplicity of structure, despite changing conditions, whereas the more complex structures, by reason of the greater delicacy of their parts, can less readily adapt themselves to altered surroundings, and therefore have a much narrower distribution both in time and space.

Next to the algæ in ascending order are those fantastic products of decay, the quick-growing, short-lived *Fungi*, animal-like in their mode of nutrition, plant-like in their fixity; then the *Lichens*, which, it is now generally agreed, are composite plants, being a special kind of parasite fungi growing on algæ. These are widely spread, living after the adaptive manner of simple forms, where nothing else can live, unwithered by the heat, unsmitten by the frost; redeeming the earth's desolate places, from treeless desert flats far as the lines of enduring snow; spreading their flowerless patches of richest colors in metallic-like stain over rock and ruin; incrusting the trees with tint of freshness or touch of age, with hoary fringe or mock hieroglyph; and in their decay yielding rich soil wherein fern and flowering tree may strike root.

In the *Mosses*, whose glossy, many-colored masses weave softest carpet over the earth, sharing in the service rendered by the humble lichens, the cells have become more developed into rudimentary root, stem, and leaf, manifesting still further transition toward unlikeness in parts due to division of function. But the structure is still cellular—*i. e.*, there are no tissues and fibres. The mosses represent the intermediate form between the lowest and the highest cryptogams, between the green algæ—out of which the liverworts were probably developed—and the ferns, which arose out of liverworts.

In the *Ferns*, the larger number of cells have joined together to form fibrous vessels, lengthening of thickening in varying shape and texture, according

to the functions to be discharged by them, resulting in the woody tissue which enters into the structure of all the higher plants. The cells which are thus converted into tissue cease to grow; the formative protoplasm becomes the formed, having given up its life for the plant, and locked up in the compacted material a store of energy for service both within the plant and by the agency of the plant. The ferns and clubmosses and horsetails of the present day are the dwarfed representatives of the stately and luxuriant, although sombre, flowerless trees that composed the dense jungles of green vegetation in the *Devonian* and succeeding *Primary* periods. These are distinguished as the Era of Fern Forests, during which our fossil fuel was chiefly formed; and although the palm-like vegetation of the tropics more nearly approaches its *Devonian* prototype, it falls far behind it in size and abundance.

II. The *Phanerogams* have their flowers with stamens and pistils conspicuous, and are divided, according to the formation of their seeds, into:

1. *Gymnosperms*, or naked-seeded, the ovules not being inclosed within a seed-vessel or ovary, but carried upon a cone, as in pines and allied species.

2. *Angiosperms*, or cover-seeded, the ovules being inclosed within an ovary.

This group is subdivided into (*a*) plants having one seed leaf from which they are developed, as palms, lilies, orchids, grasses; and into (*b*) plants having two seed-leaves, as oaks, beeches, and all trees and shrubs not included in the foregoing species.

In naked-seeded plants the pollen or male element

falls on the exposed ovules; in cover-seeded plants it falls on the stigma, passes down the pistil into the seed-vessel, and enters the ovule through an opening in it called the microphyle, or "little gate."

While the gymnosperms are, on the one hand, most nearly allied in the order of descent to ferns, the sombre flowers which they bear giving them, only by strict botanical classification, a place among phanerogams, they are, on the other hand, more complex in structure than the single seed-leaf plants, because their bark, wood, and pith are clearly defined, as in the double seed-leaf plants. Their lowest representatives comprise the cycads or palm-ferns, so called from their resemblance to palms, for which, with their crown of feathery leaves, they are often mistaken. Next in order is the much more varied and widely distributed conifer family, notably pines, firs, and larches, and, lesser in importance, cedars and cypresses. A still higher class, various in its modes of growth, marks the transition to angiosperms, the flowers of both having many features in common.

The single seed-leaf angiosperms have no visible separation of their woody stuff into bark, stem, and pith, and have no rings of growth, the wood exhibiting an even surface, dotted over with small dark points. Their leaves have parallel veins or "nerves," as in the onion and tulip, and the blossom-leaves, or petals, are grouped in threes or multiples of three. Among their several representatives we may single out the lilies for their beauty and fragrance, and the cereals for their value and importance, both classes being in near connection, since the grasses from

which man has developed wheat, barley, oats, rice, and maize are, in a botanical sense, degenerate descendants of the lily family.

The double seed-leaf plants include all the highest and most specialized varieties. Bark, stem, pith, and concentric rings of growth are clearly defined; the leaves are netted-veined, and the petals grouped in fours or fives or multiples of these numbers. The lowest class, represented by the catkin-bearers, as the birch and alder, the poplar and the oak, and by plants allied to the nettle and to the laurel, are nearly related to the highest gymnosperms. Next in order are the crown-bearers, or flowers with corollas, as the rose family, which includes most of our fruit yielders, from strawberries to apples; while the highest and most perfect of all are plants in which the petals are united together in bell-shape or funnel fashion. Such are the convolvulus and honeysuckle, the olive and ash, and at the top of the plant-scale, the family of which the daisy is the most familiar representative. Its position among plants corresponds to man's position among animals. As he, in virtue of being the most complex and highly specialized, is at their head, albeit many exceed him in bulk and strength, so is the daisy with its allies, for like reasons, above the giants of the forest.

The primary function for which the organs of plants known as flowers exists is not that which man has long assumed. He once thought that the earth was the centre of the universe until astronomy dispelled the illusion, and there yet lingers in him an old *Adam* of conceit that everything on the earth has

for its sole end and aim his advantage and service. Evolution will dispel that illusion. But our delight in the colors and perfumes of flowers will not be lessened, while wonder will have larger field for play in learning that the colored leaves known as flowers, together with their scent and honey, have been developed in furtherance of nature's supreme aim—the preservation and increase of the species. And truly the contrivances to secure this which are manifest in plant-life are astounding even to those who perceive most clearly the unity of function which connects the highest and lowest life-forms together. It is difficult, nay, wellnigh impossible, to deny the existence of a rudimentary consciousness in the efforts of certain plants to secure fertilization. Take, for example, the well-known aquatic plant, *Vallisneria spiralis*. When the male flowers detach themselves and float about the water, the female flowers develop long spiral stalks by which to reach them, and become fertilized by the discharge of pollen on their pistils. Most flowers have their male and female organs within the same petals, and in some cases fertilize themselves by scattering the pollen from the bursting stamens on the stigma or head of the pistil. But nature is opposed to this; “tells us in the most emphatic manner that she abhors perpetual self-fertilization,” with its resultant puny and feeble offspring; and we find a number of contrivances to prevent this, and to secure fertilization by the pollen of another plant, to the abiding gain all round of the plant, whose blood, as we may say, is thus mixed with that of a stranger. Two agencies—insects and the

wind—undesignedly effect this; while in the dispersion of the matured seed, birds and other animals play an important, although equally unconscious, part.

Plants which are wind-fertilized have no gayly colored petals or sepals, and do not secrete water. Such are the naked-seeded groups whose sombre flowers are borne on dull brown cones; and, among cover-seeded groups, grasses and rushes, with their feathery flowers; and willows and birches, with their long waving clusters of catkins. All of these provide against the fitfulness of the wind, which is as likely to blow the pollen one way as another, by producing it in large quantities.

Plants which are insect-fertilized seek to attract their visitors by secreting honey and developing colored floral organs. The way in which this came about is probably as follows:

The common idea about flowers is that they are made up of petals and sepals, whereas the *essential* parts are the stamens and pistils—*i. e.*, the male, or pollen-producing organs, and the female, or seed-containing organs. The earliest flowers consisted of these alone, having no colored whorl of petals within another colored whorl of sepals, but were only scantily protected by leaves, as are many extant species. These the food-seeking insects then, as now, visited for the sake of the pollen, to the detriment of the plant, which lost the fertilizing stuff and gained nothing in return. To arrest this, certain plants began, especially when in the act of flowering, to secrete honey and store it in glands or nectaries, or

near their seed-vessels, where the insects could not get at it without covering their bodies with some of the pollen, which they rubbed on the pistils of the plant next visited, and thus fertilized the ovule, provided that the plants were nearly related. Honey is sweeter to the taste than pollen, and the plants that produced the most honey stood the better chance of visits from insects, and therefore of fertilization, to the advantage of this species over others. As a rule, those which secrete honey have hairy coverings at the base of the petals, or other contrivances to prevent it being washed out by the rain or dew, or seized by useless insects, and we find curious interrelations established between plants and their desired visitors. Certain flowers adapt themselves to certain insects, and *vice versâ*, as where the plant has secreted the honey at the bottom of a long tube and the insect has developed a correspondingly long proboscis to gather it. By these and kindred devices the pollen is preserved for its sole function, the energy of the plant being conserved in the smaller quantity which it has to produce. As the honey was secreted as counter-attraction to the pollen, so the colored floral envelopes were developed to attract the insects to the honey-secreting plant, and those floral whorls, both of petals and sepals, are modified or transformed stamens which have exchanged their function of pollen-producers for that of insect-allurers. And as both stamens and pistils are leaves aborted or modified for the special function of reproduction, Goethe's well-known generalization that the leaf is the type of the plant has a large measure of truth in it.

But before speaking further about color-development in plants, it may be useful to say a little about color itself. Since everything is black in the dark, and moreover has no color in itself, it follows that color is in some way a property of light. Now light, which is itself invisible, is due to vibrations or oscillations set up in all directions by any luminous body—whether the sun or a rushlight—in the ethereal medium which pervades all space, and is composed of rays of different refrangibilities—*i. e.*, change of direction in passing from one medium to another. White light is due to a combination of all these rays, ranging through innumerable gradations of color, from red to violet, and it is to the absence of one or more of them that the infinite variety of colors is due. If a body is quite opaque, or otherwise so constituted as to absorb none of the rays, it appears white; if it absorbs them all it appears black; if it absorbs green, blue, and violet, and not red, it appears red; if it absorbs red, orange, and violet and returns or reflects green, it appears green. The colors which bodies reflect are therefore regulated by their structure; the way in which their molecules are arranged determines the number and character of the light vibrations or ether waves which are returned to the eye and which rule the color we see—*e. g.*, charcoal and the diamond are both pure carbon; the dull opacity of the one and the trembling splendor of the other are solely due to the arrangement of the several molecules of each.

It is thus obvious that any change in the nature or structure of a thing is accompanied by change in its

color, and to this cause the various pigments in plants are to be referred.

All growth involves expenditure of the energy which the plant has stored within itself, and which becomes active when the hydrocarbons combine with oxygen, resulting in cellular change, and appearance of other colors than the green, which is due to chlorophyl. Thus may be explained the color of sprouting buds and young shoots and the more or less intensified colors of leaves and flowers—one and all due to oxidation, the minutest changes inducing subtle variations in color.

Whichever plants made the most show of color would the sooner catch the eye of insects, however dim their perception of the difference in colors might be, and would thus get fertilized before plants which made less display. Thus have insects been the main cause in the propagation of flowering plants; the plants in return developing the color-sense in insects. The flower nourishes the insect, the insect propagates the flower. Other contrivances to meet the need for fertilization might be cited, as the markings upon the petals to guide the insect to the nectary; the exhalation of scent by inconspicuous flowers, or by such as would attract visitors at night, and so forth; but enough has been adduced to show what is the chief, if not the sole, function discharged by flowers—the attraction of insects to aid in securing cross-fertilization. Nor does the provision stop here. The fertilized seed is not left to chance, but, like the fertilizing pollen, is intrusted to secondary agents, to the care of the birds and the breezes. Where

not scattered by the bursting of the ovary it is winged with gossamer shafts, as in the dandelion, and carried by the wind, floated on gentlest zephyr or rushing storm to a genial soil. Such wind-wafted seeds, like wind-fertilized flowers, are rarely colored; neither are the seeds of the larger trees, since their abundance ensures notice by food-seeking animals; nor the nuts, which are protected by shelly coats. But other seeds inwrap themselves in sweet pulpy masses, called fruits, whose skins brighten as they ripen, and attract the eye of fruit-loving birds and beasts. The seeds pass through their stomachs undigested, and are scattered by them in their flight over wide areas. As with the brightest-hued and sweetest-scented flowers, so it is with the brightest and juiciest fruits; they sooner attract the visitor whose services they need, and thus gain advantage over less-favored members of their species, developing by the selective action of their devourers into the finest and pulpiest kinds.

PLANT GEOGRAPHY

—LOUIS FIGUIER

WE can distinguish in Europe three great botanical regions. 1. The region of the North; 2. The Middle region; and 3. The region of the South, or Mediterranean.

The Northern region comprehends Lapland, Iceland, Sweden, Norway, and the northern provinces of Russia. The vegetation is monotonous; the ligneous species form only the one-hundredth part

of the plants; the cryptogams predominate. The trees are principally coniferous and amentaceous. The oak, the hazel, and poplar are arrested at 60° N. lat.; the beech, the ash, and the lime at 63° ; the conifers at 67° ; barley and oats can be cultivated up to 70° . Spitzbergen, the most northerly island of Europe, situated between $76^{\circ} 30'$ and 81° , contains only ninety-three species of phanerogamous plants, belonging principally to the families of *Graminaceæ*, *Cruciferaæ*, *Caryophyllaceæ*, *Saxifragaceæ*, *Ranunculaceæ*, and *Compositæ*. Among these plants there is scarcely a single tree or shrub, but only an undershrub, *Empetrum nigrum*, and two small creeping willows.

Martius, to whom botanical geography is indebted for many valuable observations, made a voyage along the western coast of Norway, from Drontheim to North Cape, in recording which he has traced with a vigorous hand the picturesque vegetation of that country. "While disembarking I was much surprised to see cherry-trees bearing fruit about the size of peas. Lilac, mountain ash, black currant, and *Iris germanica* were covered with expanding flowers. My astonishment ceased, however, when I learned that the spring had been a very fine one. The most common tree in the gardens and streets is the mountain ash. I remarked also four oaks (*Quercus Robur*), which appeared to suffer from the cold; in fact, upon the west coast of Norway the northern limit of the oak lies half a degree south of Drontheim. The ash is a more hardy tree, but it never attains the dimensions of the oak in Sweden,

and in latitude $61^{\circ} 18'$ I noted the last of them. The lime lives at Drontheim, as do the poplar (*P. balsamifera*) and the horse chestnut; the lilac blooms in every garden. All fruit trees can only be cultivated as espaliers. Even in the most favored situations, the apple, pear, and plum do not ripen every year. In the environs of Drontheim, groups of elder, birch, fir, intermingled with ash, maple, aspen, bird-cherry, hazel, juniper, and willow crown the heights. The fields are dry and well exposed, while the meadows occupy the lower ground.

"Toward the north I pushed on to Cape Ladehamer, which is crowned with light-foliaged birches. In the fields and by the roadsides I found a great many plants which occupy similar situations in France. Nevertheless," he continues further on, "the eye of the botanist was rejoiced by the sight of a vegetation belonging at once to the Flora of the Boreal regions of the Alps and of the seashore." In the thickets grow *Geranium sylvaticum*, *Aquilegia vulgaris*, *Aconitum septentrionale*, *Pedicularis lapponica*, *Trientalis europæa*, *Paris quadrifolia*; in the less sheltered places, *Cornus suecica*, *Vaccinium Vitis-idæa*, *Polygonum viviparum*; in the marshes, the Bleaberry and *Geum rivale*; upon the sandy seashore, *Plantago maritima*, *Glaux maritima*, *Elymus arenarius*, *Triglochin maritimum*, and many others equally interesting to the botanist.

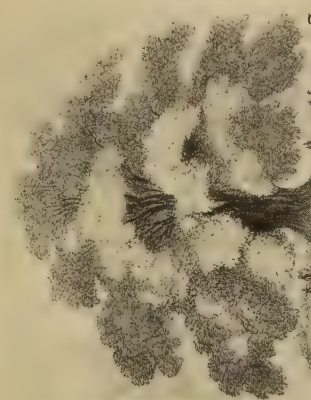
"At Bodoë, in $67^{\circ} 16'$," he continues, "I saw for the first time houses covered with turf, upon which grew many tufts of grass. According to my custom, I first examined the cultivated vegetables, but I saw



1



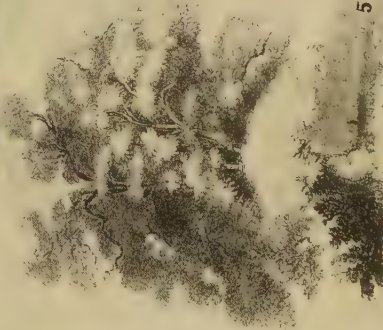
2



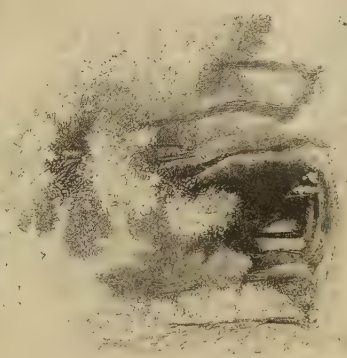
3



4



5



6

Six Familiar Tree Forms

1. Willow; 2, Oak; 3, Sycamore; 4, Cedar; 5, Chestnut; 6, Olive

only a few potatoes, peas, radishes, a few gooseberry-trees without fruit, and some fields of barley and rye. In the meadows just above the sea-level I found some plants which would have demonstrated to me, in the absence of other proofs, how much the climate of this country approaches that of the most elevated Alpine regions.

"At Hammerfest, which is under $70^{\circ} 48'$ north latitude, all attempts at cultivation had disappeared. The energies of the place are turned to commerce; it is from curiosity rather than for profit or utility that a few vegetables are cultivated.

"Near the city I observed rich meadows, that were cut once a year, and some herds of half-wild reindeer, which grazed and roamed about freely. We shall deceive ourselves, however, if we consider Hammerfest a dull or melancholy city. Its principal streets, on the contrary, consist of very fair new wooden houses, well ordered, and in all respects comfortable. These are the habitations of the better class of inhabitants. The houses of the lower classes are poorer and older; borrowing, however, a particular charm from the flowery turf with which they are covered. The roofs are formed of great squares of turf, on which a number of plants have germinated and grow vigorously. In seeing these aerial gardens I have for the first time been able to comprehend the phrase '*in tectis*,' which often occurs in the writings of Linnæus, indicative of the locality. In short, it was upon the roofs of houses that the learned botanist of Upsala herborized at Hammerfest; indeed, I frequently borrowed a ladder myself

from the proprietor in order to gather the plants which grew round the chimney of one of these picturesque old houses. What I often found there were *Cochlearia anglica*, *Lychnis diurna*, *Chrysanthemum inodorum*, Shepherd's Purse, *Poa pratensis*, and *P. trivialis*. In autumn, when the flowers of *Chrysanthemum inodorum* are in full bloom, these hanging meadows rival in beauty those of our own more genial climate, and give the city a smiling physiognomy which contrasts most happily with the severe aspect of surrounding Nature. *Ranunculus glacialis*, *Arabis alpina*, *Silene acaulis*, *Saxifraga nivalis*, Bilberries, *Diapensia lapponica*, *Salix reticulata*, *S. herbarcea*, etc., grow in the neighborhood.

"How great was my surprise on landing at the North Cape, in latitude 71° , to find myself in the middle of the richest subalpine meadows that can be imagined! high and tufted grass, which reached my knees. I found here, in short, at the northern extremity of Europe, the flowers which had so often attracted my admiration at the foot of the Swiss Alps; there they were, as vigorous, as brilliant, and much larger than among the mountains."

The mid-European region includes southern Russia, Germany, Holland, Belgium, Switzerland, the Tyrol, and the British Isles, Upper Italy, and the greater part of France. This region, whose exact limits it would be difficult to trace, is very different from the preceding. It is milder, more temperate; its woods and forests consist essentially of oak (*Quercus Robur*), to which we may add chestnut, beech, birch, elm, hornbeam, alder, etc.; but the oak

predominates. These trees, all of which lose their leaves during winter, give to the landscape a very peculiar feature, varying with the season. This region is especially favorable to the cultivation of the cereals. An oblique line, drawn from east to west, with certain inflections of its course, but ranging between the forty-seventh and forty-eighth parallel, and inclining a little toward the north, would divide it into two zones—one, the Northern, in which the vine and the mulberry yield to the rigor of winter, whose forests are chiefly composed of conifers, where the culture of the apple and pear takes their place, and which includes more *Cyperacæ*, *Rosacæ*, and *Cruciferæ*; the other, the Southern, characterized by the culture of the vine, the mulberry, and the maize, and in which *Labiataæ* begin to predominate.

In the Southern region, the Mediterranean forms the centre. It is a vast basin, whose shores present a vegetation which, if not identical, is at least analogous in its whole extent. *Labiataæ* abound there, and in certain seasons the air is filled with their sweet perfume. To this extensive family we may add a large number of *Caryophyllacæ*, *Cistacæ*, *Liliacæ*, and *Boraginacæ*. The Mediterranean draws its distinctive character, however, from the vast extent of uncultivated country, where the kermes oak, *Phillyrea*, the evergreen oak, and various half frutescent *Labiataæ*, reign supreme. These plants more especially abound in Italy, Spain, Greece, Algeria, and in the northern portion of Asia Minor. Nevertheless, a new vegetation makes its ap-

pearance at Rhodes and Jaffa, which becomes closely connected with that of Egypt. The vegetation of the Mediterranean often presents itself with a smiling and agreeable aspect. Clumps of odorous myrtles, *Arbutus*, and *Vitex Agnus-castus*, frequently occur on its shores; magnificent oleanders, whose praises have been sung by the poets, occupy the edges of the brooks. In Italy, Sicily, and Spain, the orange-trees bear without cessation flowers and fruit. The prickly pear (*Opuntia vulgaris*), and the American *Agave*, naturalized here, form impenetrable hedges in the southern parts of these countries, to which they give a marked and very characteristic landscape. The forests consist essentially of the evergreen oak (*Quercus Ilex*), whose persistent leaves remain until after their third year, and whose acorns, which have a very agreeable taste, form a considerable portion of the people's food, and of the cork-tree (*Quercus Suber*), mixed with other characteristic trees and shrubs, such as *Erica arborea*, numerous species of *Cistus*, with ephemeral flowers, often large and of dazzling brilliance, and of *Cytisus*, *Genista*, etc.

Among the other species characteristic of these happy regions we may cite the cypress (*Cupressus*), the Aleppo pine, the stone pine, planes, the olive, which we scarcely meet with elsewhere; mastic-tree (*Pistacia lentiscus*), and the pomegranate (*Ceratona Siliqua*), etc.

Over a great part of the south coast of Sicily, a palm, the *Chamærops humilis*, with fan-like foliage, waves sometimes beside the date, from the bosom of

a clump of oranges and citrons, its tall stipe crowned with an elegant panicle of drooping and feather-like leaves.

It would require a volume to give even an idea of the rich and varied vegetation of Asia. We must limit ourselves to a rapid glance of the features most characteristic of its Northern, Central, and Southern divisions.

The Northern region, or Siberia, forms a botanical region in close connection with the northern region of Europe in the one direction, and with its own middle region in the other. It has its own peculiar character, nevertheless, from the predominance of certain families, such as *Leguminosæ*, *Ranunculaceæ*, *Cruciferæ*, *Liliaceæ*, and *Umbelliferæ*. Some genera are remarkable for the number of their species; we may quote *Astragalus* among the *Leguminosæ*; *Spiræa* among the *Rosaceæ*; and *Artemisia* among the *Compositæ*. Considering that the mean temperature varies from 29° to 46° Fahr., we can not reckon on a condition of vegetation very varied. Forests are formed by larch, spruce, *Pinus Cembra*, *P. sibirica*, *P. sylvestris*, etc.; white and balsam poplars and isolated balsamic plants, dwarf birches, service-trees, alder buckthorn, alders, willows, accompany them, while whortleberries and rhododendrons form the under-shrubs. The flora of the steppes of Kamtchatka does not differ materially from that of the pasturages of central Europe. According as the spectator expects these to be rich or sterile, he is the more or less surprised to find stately tulips and graceful irises mingling

with the grassy turf in spring, but the wormwood (*Artemisia*) and other monotonous forms of vegetation succeed them.

Humboldt assigns to the forests of the Ural the vegetation characteristic of a park. "They present," he says, "an alternation consisting of a mixture of needle-leaved and round-leaved trees, and lawns; an assemblage which is completed by masses of brushwood, formed by wild roses, honeysuckles, and junipers, while *Hesperis*, *Polemonium*, *Cortusa*, *Mathioli*, magnificent primroses, and larkspurs form a perfect carpet of flowers; while the water buck-bean, with white blossoms, is the grace of the marshes." He saw also "on the banks of the Irtisch great spaces entirely colored red by *Epilobium*, with which were associated tall-stemmed larkspurs (*Delphinium*), with blue flowers, and the fiery-scarlet *Lychnis chalcidonica*."

The Central region consists of northern China and Japan. The magnolias—those grand-leaved trees, with magnificent flowers and delicate aroma, which give such an attractive feature to gardens where they can be cultivated—are natives of this vast region. So is the camellia, which has been, as it were, naturalized in the greenhouses of Europe, whose ever-green, glossy, and persistent foliage is the admiration of travelers, and of which we may reckon upward of 700 varieties; and the tea-plant (*Camellia Thea*), of whose leaves so many millions of pounds are annually imported into Europe. Also the *Aucuba*, with coriaceous leaves and clustered flowers, so ornamental in our gardens and shrubberies; *Celastrus*,

hollies, spindle-tree, *Lagerströmia*, *Spiræa*, *Elæagnus*, etc.

The most remarkable trees and shrubs besides these are the palm, *Raphis flabelliformis*; the paper mulberry (*Broussonetia papyrifera*); *Osmanthus*, whose flowers are employed to give flavor to tea leaves; the ebony-tree (*Diospyros Kaki*), with white flowers, and berries of a cherry-red, and of a delicious flavor; the loquat (*Eriobotrya japonica*); *Salisburia adiantifolia*, which is planted round the temples; yews (*Taxus nucifera* and *verticillata*); cypress (*Cupressus japonica*); junipers, thujas, oaks (*Quercus glabra* and *glauca*); *Alnus japonica*, *Juglans nigra*, and several species of laurels and maples.

Among the cultivated plants we find rice, wheat, barley, oats, *Sorghum vulgare*, Sago (*Cycas revoluta*), taro (*Caladium esculentum*), *Convolvulus Batatas*, apple, pear, quince, plum, apricot, peach, orange, radish, cucumber, gourds, watermelons, anise (*Pimpinella Anisum*), peas, beans, hemp, and cotton (*Gossypium herbaceum*—a remarkable mingling of vegetable productions, which transports us at one moment from Asia to Europe, and at the next from America to Asia. We might dwell upon a crowd of ornamental plants, many of which are now well known in Europe, as the *Glycine*, the lily of Japan, tiger lily, and Chinese primrose.

The Southern region of Asia comprehends the two Indian peninsulas. Here non-tropical species disappear, or only present themselves very rarely. Tropical families become more numerous; the trees cease to lose their leaves; ligneous species are more

numerous than without the tropics; the flowers are larger, more magnificent; climbing, creeping, and parasitic plants increase in number and size. India may be considered the true country of aromatic plants. Nor is the rich soil less fruitful in the production of suitable timber for constructive purposes.

Among the most abundant arborescent plants in this botanical region are *Bombax*, *Şapindus*, *Mimosa*, *Acacia*, *Cassia*, *Jambosa*, *Gardenia*; ebony (*Diospyros Ebenus*) has been celebrated for its black-colored solid wood from the most ancient times; *Bignonia*; teak (*Tectona grandis*), is a magnificent tree, which furnishes timber well adapted for building purposes from its great endurance; *Isonandra Gutta* produces *gutta-percha*; laurels have an aromatic bark; the nutmeg-tree (*Myristica*) produces seeds which are employed as spice; figs (*Ficus religiosa, indica, elastica*); palms, such as the *Borassus* (*Borassus flabelliformis*) with magnificent large fan-like leaves; *Sagus*, whose soft pulp yields sago, a farinaceous product very rich in starch; *Calamus*, whose twining and creeping stem is sometimes upward of 500 feet in length, of one uniform thickness, and of which the canes used in Europe are made; areca (*Areca Catechu*), the nut of which is a favorite masticatory with the natives; *Corypha umbraculifera*, the trunk of which, sometimes reaching the height of sixty or seventy feet, is crowned with an ample tuft of leaves spread out in umbrella form, covering a space of eighteen feet; *Dracæna*; screw-pines (*Pandanus*); last, but not least, the bamboo.

If we throw a glance, moreover, at the plants under cultivation, we find them equally important: rice, earth-nut, *Sorghum*, Indian corn, the cocoa-nut, the elegant and useful tree which gives to man almost all the necessities of life, supplying him at once with shelter, food, light, heat, and clothing; the clove-tree (*Caryophyllus aromaticus*), the unopened flower of which is the well-known clove; pepper (*Piper nigrum*), the fruit of which, gathered before maturity, has been constantly brought to Europe since the expedition of Alexander the Great; and the betel (*Chavica Betel*), with bitter and aromatic leaves, in which the southern Asiatics inclose a few slices of the areca-nut, which they chew; the tamarind (*Tamarindus indica*), a magnificent tree, the fruit of which incloses a pulp of acid flavor; the mango (*Mangifera indica*), whose much-vaunted fruit has a sweet and richly perfumed flavor accompanied with a grateful acidity; the mangosteen (*Garcinia Mangostana*), whose berry incloses, under a bitter and astringent epicarp, a delicious pulp; the banana, whose yellow-clustered fruit, each six or eight inches long, furnishes a very nourishing food; the rose apple (*Jambosa vulgaris*), the guava (*Psidium pomiferum*), with yellow fruit of the size of a pear; oranges, watermelons, sugar-cane, and coffee.

Africa, like Asia, presents three very distinct regions: 1st, the Northern, which comprehends the Mediterranean littoral and the Sahara; 2d, the Central, which is tropical; 3d, the Southern, which includes the Cape of Good Hope.

The Mediterranean region, by which we mean the

African littoral bathed by the Mediterranean, includes Algeria from the northern slopes of the Atlas to the sea, and the Delta of the Nile. This part of Africa represents, in many respects, a vegetation analogous to that of South Europe. In the mountain region of North Africa all the plants of Central Europe may be cultivated with advantage. The vine prospers in the neighborhood of Tlemcen, Milianah, Mascara, and Medeah, where the colonists and even the natives have undertaken its cultivation. The olive, so generally spread over North Africa, constitutes one of the chief sources of wealth to the Kabyle tribes. The cork-tree forms immense forests in the lower mountain region of the littoral: in the province of Constantine, gathering the cork has become an important trade since its conquest by France. With respect to the Sahara, M. Cosson, a traveler and botanist, thus expresses himself:

“Northern Africa is especially characterized by the extreme rarity of rains, the dryness of the atmosphere, and the extremes of temperature; the absence of great ranges of mountains and of permanent water-courses gives an aspect quite special to the desert-like vegetation. The number of species growing spontaneously does not exceed 500. The greater number of these are perennials, which grow in tufts, and have a dry and sterile aspect, giving them a characteristically rugged and hard appearance. The families represented in the Algerian Sahara in greatest number are *Compositæ*, *Graminaceæ*, *Leguminosæ*, *Cruciferaæ*, and *Chenopodiaceæ*. Among the ligneous species are Tamarisks, a genus of ele-

gant flowering shrubs, and the *Pistacia atlantica*. The date-tree is, however, the chief source of wealth in the gardens of the oases. This tree is cultivated, not alone for the abundance and variety of its products, but also for its shade, which secures other cultivated plants from the violence of the winds, and maintains in the soil the moisture required for the cultivation of other crops.

“Besides the date, an oasis generally presents an abundant crop of figs, pomegranates, apricots, frequently the vine. The peach, the quince, the pear, and the apple, are planted in gardens, and in the oases, the citron, the orange-tree, olives, barley, more rarely still, wheat, are cultivated in the irrigated lands of the neighborhood, and in the intervals between the date plantations. Onions, beans, carrots, turnips, and cabbages, occupy a large place among the plants cultivated. Pimento is also largely cultivated for the stimulating properties of its fruit, which render it a favorite condiment with the Arabs. The egg-plant and the tomato are cultivated in some gardens for their fruit. Numberless species of *Cucurbitaceæ* are also sown in the gardens in summer, and sometimes attain a great size. The gombo (*Hibiscus esculentus*) is cultivated here and there by the negroes for its mucilaginous fruit. The industrial and fodder plants are principally hemp, represented by a dwarf variety (Haschich), which is not employed as a textile plant, but its extremities are smoked by some of the less fervent Mussulmans. Tobacco is also cultivated. Henna (*Lawsonia inermis*), the leaves of which have been employed in

dyeing a black color, scarcely exists except in the oasis of Ziban."

The Central region is only very imperfectly known, in consequence of the terribly insalubrious nature of its coast. The same forms of vegetation, however, prevail there which are found in other tropical regions. We may remark here that the plants, which are usually herbaceous in countries without the tropics, become ligneous in these regions. This is the case with plants of the families *Rubiaceæ* and *Malvaceæ*. We note here also the almost entire disappearance of *Cruciferae* and *Caryophyllaceæ*. The prevailing families are *Leguminosæ*, *Terebinthaceæ*, *Malvaceæ*, *Rubiaceæ*, *Acanthaceæ*, *Capparidaceæ*, and *Anonaceæ*. If we take a glance at prevailing vegetation proper to this region of Africa, we find upon the humid coasts impenetrable forests formed of mangroves (*Rhizophora Mangle*), and *Avicennia tomentosa*, *Musa*, *Canna*, *Amomum*, *Pandanaceæ*, gigantic *Malvaceæ* (such as the baobab), *Bromeliaceæ*, *Aroideæ*. Aloes (*Aloe socotrina*) furnishes the aloes of medicine; and several fleshy Euphorbias impress their strange characteristics upon the vigorous vegetation of this region.

It would be depriving African vegetation of its richest ornament not to mention its admirable palms. At their head stands the oil palm (*Elæis guineensis*), the fruit of which, of the size of an olive, contains so much oil that the liquid flows out when it is pressed between the fingers. The seed contains a sort of butter. The sap of this precious tree yields an excellent wine; its leaves prove excellent food

for sheep and goats. But the true palm wine is produced from *Raphia vinifera*. Another remarkable member of this elegant family is *Lodoicea Seychellarum*, the fruit of which is larger than a man's head and weighs upward of twenty pounds; it sometimes floats as far as the coast of India. It is a fact worthy of remark that in this region very few ferns or orchids are observed, and yet these groups of plants are extremely numerous in other tropical countries.

Among the exotic vegetables which are successfully cultivated in central Africa we may reckon maize, rice, *Sorghum*, Indian corn, manioc, *Caladium esculentum*, belonging to the family of the *Araceæ*, the rhizome and leaves of which are alimentary; the banana, the mango, the papaw-tree (*Carica Papaya*), the fruit of which, about the size of a small melon, is eaten either raw or cooked, and the pulp mixed with sugar forms a delicious marmalade; the pineapple, figs, coffee, sugar-cane, ginger, various species of *Dolichos*, the earth-nut, cotton, tobacco, and the tamarind.

The Southern region of the Cape of Good Hope is the country of the species of *Protea*, *Pelargonium*, *Epacridaceæ*, *Oxalis*, and *Ixia*, which decorate our hothouses and parterres. No other country can compare with this region for the prodigious abundance and dimensions of its heaths. While the plains of Europe, the Alps included, scarcely yield a dozen species, at the Cape there are many hundreds. They attain sometimes the height of fifteen or sixteen feet. Their leaves are small, inconspicuous, and acicular;

but their flowers are large, and the colors which decorate them brilliant in the extreme, varying from the softest shades to dazzling ones.

The flora of this region is rich in vegetable forms, but it is by no means smiling in its aspect. We find no true forests, grand and sombre, in the whole region; there are few creeping plants, but, on the other hand, there are many succulents. The most characteristic families are the *Restiaceæ*, *Iridaceæ*, *Proteaceæ*, *Ericaceæ*, *Mesembryanthaceæ*, *Rutaceæ*, *Gernaiaceæ*, *Oxalidaceæ*, and *Polygalaceæ*. Among the characteristic genera we may mention the *Ixia*; *Gladiolus*, with their sword-shaped leaves and party-colored flowers; *Strelitzia*, so remarkable for their inflorescence, and for their blue and yellow flowers; *Protea*, so named for their diversity of appearance; *Leucadendron*, of which one species, *L. argenteum* (the silver-tree), rises to the height of from thirty to forty feet, its branches bearing lanceolate leaves, silky and silvery; *Helichrysum* and *Gnaphalium*, corymbiferous composites, better known as *Immortelles*; *Mesembryanthemum*, or ice-plants; *Stapelia*, leafless asclepiads, with angular fleshy stem and showy flowers, but somewhat fœtid odor; *Phyllica*, a genus of Rhamnads somewhat resembling heaths, with abundant evergreen foliage and small cottony heads of white flowers; *Pelargonium*, of which an infinite variety of forms, the result of culture, are known; *Oxalis*, the evergreen *Sparmannia*, whose white flowers, stamens with purple filaments and irritable anthers, are so ornamental in orangeries. It is upon the sandy coast of this curious botanical

region that the species of *Stapelia*, *Iridaceæ*, *Mesembryanthemum*, and *Diosma* abound. The heaths and crassulas grow upon the slopes of the mountains.

The cultivated plants are the cereals, most of the fruits and vegetables of Europe, the sorghum of Kaffirland, yam, banana, tamarind, and guava.

Vegetation is richer and more varied in America than in any other part of the globe. Beginning with North America, we find its polar vegetation quite analogous to that of Europe and Asia under the same latitudes. The willow, birch, and poplar, exposed to the persistent action of the cold, become stunted bushes; and saxifrages, mosses, and lichens prevail.

Without dwelling on the Arctic regions, then, we may divide this immense country into two regions; one of which, descending as far as 36° , may be called the Northern region; the other, comprehended between 36° and 30° of latitude, will constitute the Southern region.

The Northern region well deserves to be called the region of *Aster* and *Solidago*; those beautiful composites abound there with *Liatris*, *Rudbeckia*, and *Galardia*, of the same family. *Oenothera*, *Clarkia*, *Andromeda*, and *Kalmia*, charming ornamental plants, well known in our flower gardens, likewise characterize this vegetable zone. Among the most abundant arborescent species, we may mention numerous species of pine, fir, larch, *Thuja*, juniper; no less than twenty-seven species of willow; twenty-five of oak, beeches, chestnuts, elms, hornbeams, alders, birches, poplars, and ashes. With these are mingled the American plane, *Liquidambar*, the

trunk and branches of which furnish juices used in medicine; the tulip-tree, with singularly truncate leaves and large, spreading, solitary, yellowish flowers; different species of maple, lime, *Robinia*, and walnut. Together with these numerous and varied arborescent species, which attain considerable dimensions, grow the *Myrica cerifera*, which furnishes an abundant wax drawn from the fruit by boiling; the currant (*Ribes*), with colored and ornamental flowers in great varieties of red, yellow, and white; the elegant *Andromeda*, *Azalea*, *Rhododendron*, and *Spiræa*, present themselves in endless varieties; sumacs, a species of which (*Rhus toxicodendron*), with greenish yellow flowers, contains a juice so acrid that contact with it produces blisters and erysipelas, and is a dangerous poison; *Ceanothus*, hollies, and buckthorns.

In the Southern region the vegetation somewhat resembles that of the tropics, being a transition between that of the temperate and torrid zones. Walnuts, elms, chestnuts, and oaks are found there, and with them three species of palms, one of which is *Chamærops Palmetto*; species of *Yucca*; of *Zamia*, among the *Cycadaceæ*; *Passiflora*; of woody twining plants, such as *Bignonia sapindus*; cacti, and laurels. Lastly, by the side of tulip-trees, *Pavia*, and *Robinia*, grow magnificent species of *Magnolia*, of which this is the true domain. The vegetation of this region is thus remarkable in its variety. The sugarcane, indigo, cotton, and tobacco cover the cultivated plains. In Missouri, Texas, Arkansas, and Mexico, the great colony of the cacti raise their lofty stems.

In this region *Cactus*, *Opuntia*, *Cereus*, *Echinocactus*, and *Melocactus*, raise their oddly branching stems and clustering flowers, the most remarkable of all doubtless being *Cereus giganteus*. It inhabits the wildest and most inaccessible regions, requiring little or no soil to attain a prodigious development. It has at first the appearance of an enormous tomahawk. Thence rises a column, three yards high, which branches off and assumes the shape of an immense candelabrum, the height of which may be twelve or thirteen yards. Mexico, according to the reports of botanists, may be divided into three regions of altitude. The first extends from the valleys as far as the oak forests—this is the region of palms, cotton, indigo, sugar-cane, coffee, and tropical fruits. The second, situated at an elevation of from 3,500 to 9,000 feet above the sea, is the temperate region. It stretches from the oak forests to the forests of *Coniferae*. At this height the temperature is still sufficient to ripen some tropical fruits. The third, or cold region, occupies a space comprehended between the Conifers and perpetual snow. In many places it possesses a climate under which pear, apple, and cherry trees, and the potato, can still grow. In ascending from the foot of Orizaba, one sees successively appear and disappear *Mimosa*, *Acacia*, cotton, *Convolvulus*, *Bignonia*, oaks, palms, bananas, myrtles, laurels, *Terebinthaceae*, tree-ferns, *Magnolia*, arborescent composites, plane, *Storax*, apples, pears, cherries, apricots, pomegranates, lemon and orange trees, orchids, *Fuchsia*, and *Cactus*.

The plains of Venezuela, known under the name of

Llanos, are principally covered with grass-like plants, such as *Kyllingia*, *Cenchrus*, and *Raspalum*. With these we find a few dicotyledonous plants, such as *Turnera*; some *Malvaceæ*, and, what is very remarkable, species of *Mimosa*, with leaves quite sensitive to the touch, which the Spaniards call *Dornuderas*. The same race of cows which in Spain fatten upon sainfoin and clover, here find excellent nourishment in the herbaceous sensitive plants. The pasturage is richest, not only near rivers subject to inundations, but also where the trunks of the palm-trees are the most crowded, which can not be attributable to the shelter and protection which they have from the sun's rays, since the palm of the Llanos (*Corypha tectorum*) has only a very few corrugated and palmate leaves, like those of *Chamærops*, and the lower are always parched and dried up. Besides the isolated trunks of palms we also find, here and there, in the Llanos, groups of palms, in which the *Corypha* mingles with a tree of the family of *Proteaceæ*—a new species of *Rhopala*, with hard and resonant leaves. In the Llanos of Caracas, the *Corypha* extends from the Mesa de Paja to Guaya-val. More to the north and northwest it is replaced by another species of the same genus, with leaves equally palmate, but much larger. To the south of Guaya-val other palms predominate, chiefly the pinnate-leaved *Piritu* (*Guilielma speciosa*) and the *Mauritia flexuosa*, the sago-tree of America, which supplies farinaceous food, good wine, thread to weave into hammocks, clothes, and baskets; its fruit, in shape resembling pine-cones, being covered with

scales, like those of *Calamus* (Rotang), with something of the taste of an apple. The Guaranés, whose very existence, so to speak, depends on the Murichi palm, obtain an acid and very refreshing fermented liquor from it. This palm has large, shiny, corrugated, and fan-like leaves, maintaining a most beautiful verdure in times of the greatest drought. The sight of it alone in the Llanos produces an agreeable and refreshing sensation; and the Murichi, laden with its scaly fruit, contrasts singularly with the sad aspect of the palm of Cobija, the leaves of which are always gray and covered with dust.

If we ascend the Andes, between 20° south latitude and 5° north, at a height of from 5,000 to 10,000 feet above the sea level, we shall find extra-tropical forms of vegetation become more abundant: *Graminaceæ*; some *Amentaceæ*—such as the oaks, willows; *Labiataæ*; *Ericaceæ*; numerous *Compositæ*; *Caprifoliaceæ*; *Umbelliferaæ*; *Rosaceæ*; *Cruciferaæ*; and *Ranunculaceæ*. Tropical plants, on the contrary, disappear, or become very rare; but still, isolated species of palms, pepper-plants, *Cactaceæ*, passion-flowers, and *Melastomaceæ* are found at considerable heights. Among the most abundant ligneous species are the *Ceroxylon andicola*, the highest of all the palms, which reaches the height of 200 feet, and produces a wax which exudes from its leaves, and from the base of their petioles; willow and Humboldt's oak; several species of *Cinchona*, which here reign supreme; a few hollies, and species of *Andromeda*. Vegetables cultivated between the tropics, in Mexico, and as far south as the river Amazon, dis-

appear almost entirely here; but maize and coffee, the cereals and European fruits, are cultivated in these regions; potatoes; *Chenopodium Quinoa*, the seeds of which, when boiled, serve as food for the inhabitants of the mountains.

If we ascend to the height of 10,000 feet above the sea on the Andes, and in the same latitude, tropical forms of vegetation almost entirely disappear. Those, on the contrary, which characterize temperate climates, and even the Polar regions, become abundant. Large trees are no longer seen. Alders, bilberries, currants; *Escallonia*, with bitter and tonic leaves, of which this is the home; hollies and *Drymis*, are bushes belonging to these regions, as well as the curious calceolarias, with shoe-shaped corolla, the seeds of which have supplied horticulture with an infinite number of varieties. Among the characteristic families we also find *Umbelliferæ*, *Caryophyllaceæ*, *Cruciferæ*, *Cyperaceæ*, mosses and lichens. Returning to more circumscribed botanical districts, the climate of Caracas has often been called one of perpetual spring. A more delicious temperature can not be conceived. During the day it ranges between 60° and 68° Fahr., and in the night between 60° and 64°, at once favorable to the growth of the banana, the orange, coffee, the apple, apricot, and wheat.

We must not quit these regions without mentioning two beneficent trees—the *Theobroma Cacao* and the cow-tree, *Brosimum Galactodendron*. The roasted and crushed seeds of *Theobroma Cacao*, with the addition of sugar, make chocolate. Humboldt

gives the following account of the cow-tree, which has the habit of *Chrysophyllum Cainito*: "The fruit is rather fleshy, consisting of one, sometimes two nuts. When incisions are made in the trunk an abundance of thick glutinous milk flows, which is without any acidity. This substance exhales a very agreeable balsam-like odor. It was presented to us in the fruit of the Calabash-tree. We drank considerable quantities of it in the evening before going to bed, and again early in the morning, without experiencing any injurious effects. Negroes and free people who work on the plantations drink of it, and soak their maize or manioc bread in it. The master of the farm assured us that the slaves fattened visibly during the season when the *Palo de Vacca* furnishes them with most milk. Upon the arid flank of a rock," adds Von Humboldt, "there grows a tree whose leaves are dry and coriaceous, its great ligneous roots almost piercing the stone. During many months of the year not a shower waters its foliage, the branches appear dry and dead; but when the trunk is pierced a sweet and nourishing milk follows the incision."

In order to penetrate to the heart of the vegetation of Brazil, the region of palms and *Melastomaceæ*, the land of promise to the naturalists, we shall take as our guide Martius and August de Sainte-Hilaire, who have written with much exactness on the vegetable wonders displayed in the Brazilian forests. Their aspect varies according to the nature of the soil, and the distribution of water traversing them. If these forests are not the seat of a constant supply of moisture, or if the moisture is only renewed by

periodical rains, the drought stops the vegetation, and it becomes intermittent, as in European climates. This is the case in the Catingas. The vegetation of the untrodden forests, on the contrary, of which Sainte-Hilaire gives an eloquent picture, is the reverse of this; excited by the ceaseless action of the two agents, humidity and heat, the vegetation of the virgin forests remains in a state of continual activity. The winter is only distinguished from the summer by a shade of color in the verdure of the foliage; and if some of the trees lose their leaves, it is to assume immediately a new appearance. "When a European arrives in America, and sees from a distance the untrodden forests for the first time, he is astonished not to see the singular forms which he admired in European hothouses, but which are here mingled in masses and lost. And he is astonished at the little difference in the outline of the forests between those of his own country and those of the New World, and he is only struck with the proportions and the deep green color of the leaves, which, under the most brilliant sky imaginable, impart a grave and severe aspect to the landscape. In order to appreciate all the beauties of the tropical forest we must plunge into retreats as old as the world. Nothing there reminds us of the fatiguing monotony of our oak and fir forests: each tree has a bearing peculiar to itself. Each has its own foliage, and often its own peculiar shade of verdure. Gigantic specimens of vegetation, each belonging to different, sometimes to remote, families, mingle their branches and blend their foliage. Five-leaved *Bignoniaceæ* grow beside *Cæsalpinia*, and the

golden leaves of *Cassia* spread themselves in falling upon arborescent ferns. Myrtles and *Eugenia*, with their thousand-times-divided branches, are finely contrasted with the elegant simplicity of the palms; *Cecropia* spreads its broad leaves and branches, which resemble immense candelabra, among the delicate foliage of *Mimosa*. There are trees with perfectly smooth bark, others are defended by prickly spines; and the enormous trunk of a species of wild fig spreads itself out with sloping plates, which seem to support it like so many arched buttresses. The obscure flowers of our beeches and oaks only attract the attention of naturalists; but in the forests of South America gigantic trees often display the most brilliant colors in their corolla. Long golden clusters hang from the branches of the *Cassia*. *Vochysia* erect a thyrsus of odd-shaped flowers. Yellow and sometimes purple corollas, longer than those of our *Digitalis*, cover in profusion the species of trumpet-flowered *Bignonia*; and *Chorisia* is decked with flowers which resemble our lily in shape, and remind us of *Alstromeria* from the mixture of colors they present. Certain vegetable forms, which assume at home very humble proportions, present themselves with a floral pomp unknown in temperate climates; some *Boraginaceæ* become shrubs; many *Euphorbiaceæ* assume the proportions of majestic trees, offering an agreeable shelter under their thick umbrageous foliage."

But it is principally among the *Graminaceæ* that the greatest difference is observable. Of these there are a great number which attain no larger dimen-

sions than our *Bromus*, forming masses of grass only distinguished from European species by their stems being more branchy, and the leaves larger. Others shoot up to the height of the forest tree, with a graceful habit. At first they are as upright as a lance, terminating in a point, with only one leaf, resembling a large scale, at each internode; when these fall, a crown of short branches springs from their axils, bearing the true leaves. The stems of the bamboos are thus decorated with verticils at regular intervals. It is to the *Lianes* principally that tropical forests are indebted for their picturesque beauty, and these are the source of the most varied effects. Our own honeysuckle and the ivy give but a faint idea of the appearance presented by the crowd of climbing and creeping plants belonging to many different families. These are *Bignoniaceæ*, *Bauhinia*, *Cissus*, and *Hippocrateaceæ*, and while they all require a support, they each have notwithstanding a bearing peculiar to themselves. One of those climbing parasites will encircle the trunk of the largest trees to a prodigious height, the marks left by the old leaves seeming in their lozenge-shaped design to resemble the skin of a serpent. From this parasitic stem spring large leaves of a glossy green, while its lower parts give birth to slender roots, which descend again to the earth straight as a plumb-line. The tree which bears the Spanish name of *Cipo-Matador*, "the murderous Liane," has a trunk so slight that it can not support itself alone, but must find support on a neighboring tree more robust than itself. It presses against its stem, aided by its aerial roots, which embrace it at

intervals like so many flexible osiers, by which it secures itself and defies the most terrible hurricanes. Some *Lianes* resemble waving ribbons, others are twisted in large spirals, or hang in festoons, spreading between the trees, and darting from one to another, twining round them, and forming masses of stem, leaves, and flowers, where the observer often finds it difficult to assign to each species what belongs to it.

Thousands of different species of shrubs, *Melastomaceæ*, *Boraginaceæ*, *peppers*, and *Acanthaceæ*, springing up round the roots of large trees, fill up the intervals left between them. Species of *Tillandsia* and orchids, with flowers of strange and whimsical shape, make their appearance, and these often serve as supports to other parasites. Numerous brooks generally run through these forests, communicating their own freshness to the forest vegetation, presenting to the tired traveler delicious and limpid water, while the banks of the stream are carpeted with mosses, lycopodiums, and ferns, from the midst of which spring begonias, with delicate and succulent stems, unequal leaves, and flesh-colored flowers.

The forests of Paraguay, still little known, situated along the coast of the Atlantic, consist of ligneous *Compositæ* and *Ilex paraguayensis*, the Paraguay tea, of which a large quantity is annually exported.

In the Argentine Republic Auguste de Saint-Hilaire found only 500 species of plants, among which only fifteen belonged to families which are not European.

When we reach the south coast of Patagonia and

the Falkland Islands, a few brown and coriaceous *Graminaceæ* and *Cyperaceæ*, such as *Dactylis cæspitosa*, *Carex trifida*, *Bolax glebaria*, *Cardamine glacialis*, *Veronica*, *Calceolaria*, *Aster*, *Opuntia Darwinii*, *Lomaria magellanica* among the tree ferns, a few brambles, thickets of bilberries and *Arbutus*, include nearly the whole of the vegetation of these desert lands, where mosses, hepaticas, and lichens reign supreme. We now reach the southern part of South America. In the stormy region of Terra del Fuego thick forests cover the mountains, where they are sheltered from the wind, to the height of 1,500 feet above the level of the sea. *Fagus betuloides* predominates there; then comes *F. antarctica*, accompanied by barberry and currant bushes.

At the Island of Hermite, the most southerly point of the American Continent, there is still some arborescent vegetation. Hooker there observed eighty-four flowering plants and many cryptogams. A fungus parasitic on the beech (*Cyttaria Gunnii*) constitutes there a principal aliment of the miserable inhabitants of these gloomy regions.

The Australian flora presents forms more ancient than any other contemporary vegetation. More than nine-tenths of the species found between 33° and 35° south latitude, in Australia, are absolutely limited to these regions. Many constitute completely distinct families; others form families which are scarcely represented in any other part of the globe. Those even which belong to groups more generally diffused disguise their natural affinities under forms isolated and unlike their congeners. The different species of two

genera, namely, *Eucalyptus* among *Myrtaceæ*, and *Acacia* among *Leguminosæ*, form perhaps, from their number and dimensions, one-half of the vegetation which covers the country. Their leaves are reduced to phyllodes. Neither these phyllodes nor the limb of the real leaves are placed horizontally, like those of Europe and other parts of the world, but are perpendicular to the surface of the soil, so that the light shining between these vertical blades is not arrested, as in the case with our trees and bushes, in which the leaves are placed transversely one above the other. The effect produced by masses of Australian verdure is thus entirely different from that to which we are accustomed. The aspects of these forests particularly struck the first travelers who visited them, from the singular sensation communicated to the eye by this mode of distributing light and shade.

Eucalyptus, which occupies such a large place in Australian vegetation, may be said to be the sacred tree with the natives; it shadows the tombs of the savage inhabitants of these countries. Sir Thomas Mitchell, the traveler to whom we owe the first scientific description of Australia, has given a remarkable picture of "these groves of death," which are daily becoming more and more rare, and will disappear under the influence of European colonization. He relates that these groves mark the centre of the patrimonial land of each great Australian tribe. Little *tumuli* of grass, and sandy footpaths, surround the clumps of these funereal squares, over which spreads the shadow of the *Eucalyptus* and *Xanthorrhæa*. If to the magnificent *Eucalyptus* and simple-

leaved *Acacia*, which predominate in the forests and give quite a special character to the vegetation, we add the *Xanthorrhæa*, with its thick stem, long, narrow, linear leaves, curved and spreading at the summit, from the centre of which rises an elongated stem, terminated by a spike of robust flowers; the *Casuarina*, with long, pendent, and drooping boughs, most delicately articulated; *Araucaria excelsa*, whose column-like trunk and verticillate branches rise to the height of ninety or a hundred feet; the elegant *Eupacridaceæ*, with flowers so varied; a vast number of pretty *Leguminosæ*, which now add to the riches of our hothouses; more than 120 terrestrial *Orchidaceæ*, nearly all belonging to genera peculiar to Australia, we shall have an idea of the vegetation which covers and decorates in so original a way the shores of New Holland.

The large islands of New Zealand almost correspond in latitude with the zone which we have been examining. These islands are the nearest land (considering Van Diemen's Land as part of Australia), and are interesting as being the exact antipodes of western Europe, and because they repeat as it were our Mediterranean region on the other side of the globe. While resembling it in climate, however, the native vegetation has its own characteristics. It has some features in common with Australia and the tropics.

In the large island of Ika-na-Nawi there are immense forests of *Lianes* and interlacing shrubs, which render them impenetrable. In these forests there exist, no doubt, trees of gigantic dimensions, for the

canoes of the natives are sometimes as much as sixty feet long, and from three to four broad, all hollowed out of one trunk. At from two to four miles from the coast Messrs. Richard and Lesson saw large spaces, very low and probably marshy, covered with great masses of green trees, of which the *Dacrydium cupressinum* and *Podocarpus dacrydiodes* and some others, form the principal species. The European is surprised to meet there many familiar plants, or species closely allied to them, such as *Senecio*, *Veronica*, rushes, *Ranunculus acris*, etc. On the other hand, several plants peculiar to New Zealand grow abundantly in these localities, such, among others, as the *Phormium tenax*, called by Europeans New Zealand Flax, because its fibres furnish a very strong thread, much used in the manufacture of certain fabrics.

Ferns form a tenth of the number of species in the whole vegetation of New Zealand; among Monocotyledons are *Graminaceæ* and *Cyperaceæ*; among Dicotyledons, *Umbelliferæ*, *Cruciferæ*, and *Onagrariaceæ*. New Zealand only furnishes a small number of alimentary plants. The aboriginal inhabitants of this archipelago, for the most part ichthyophagous, were long reduced to the feculent root of a fern, the *Pteris esculenta*, for food, when they could not obtain fish. None of their trees produce large fruit. The taro (*Caladium esculentum*) and the sweet potato (*Convolvulus Batatas*) also serve as nourishment to the inhabitants of these countries. It is to be remarked that European vegetables, introduced into New Zealand by sailors, are propagated there with

such facility that the aspect of the ground, as well as conditions of life, are greatly modified. Among the vegetables proper to the archipelago in question we may note the *Corypha australis* among the palms; arborescent species of *Dracæna*, forests of *Coniferæ*, with large leaves, such as *Dammara*, and *Metrosideros* among the *Myrtaceæ*.

ZONES OF VEGETATION.—M. J. SCHLEIDEN

IF, from the snow-covered ice-plains of the extreme north, where the Red-snow Alga alone remind us of the existence of vegetable organization, we turn toward the south, a girdle first expands before us, in which mosses and lichens clothe the soil, and a peculiar vegetation of low plants with subterranean, perennial stems, and generally large, handsome flowers, the so-called Alpine plants, gives a special character to Nature. Almost all the plants form little, flattened, separate tufts; *Pyrola*, *Andromeda*, *Pedicularis*, *Cochlearia*, poppies, crow-foots, and others are the characteristic genera of this flora, in which no tree, no shrub flourishes. Leaving this region, which botanists call the region of Mosses and Saxifrages, or, after one of the founders of Geographical Botany, Wahlenberg's region, we go southward, and at first we see little low bushes of birches, then more compacted woods, into which the pines and other coniferous trees assemble, and we at last find ourselves in a second great zone of vegetation which is characterized by the woods consisting almost

exclusively of conifers, which thus impress a peculiar character upon the flora; firs and pines, Siberian stone-pines and larches form great widely extended masses of forest; by brooks and on damp soil occur the willow and the alder. On dry hills grow the reindeer lichen and Iceland moss. In the cranberry, cloud-berry, and the currant Nature gives spontaneously, though sparingly, food; and a rich flora of variegated flowers serves for the decoration of the zone, which stretches, in Scandinavia, to the northern limit of the cultivation of wheat, but in Russia and Asia, almost to Kazan and Yakutsk; we will call it the zone of the conifers. Even in the neighborhood of Drontheim, the culture of fruits begins, though sparingly; soon appears the sturdy oak, called, with rather too much poetic license, "the German"; in Schoonen, Zealand, Schleswig, and Holstein flourish the first woods of beech. In about the latitude of Frankfort-on-the-Main, another tree joins company, which, in its bold, picturesque mode of branching, takes its stand beside the oak—which in the beauty of its foliage, as well as the utility of its fruit, it far surpasses—namely, the noble chestnut. The Pyrenees, the Alps, and the Caucasus form the southern limit of the zone, in the more eastern portion of which the lime and the elm contribute so abundantly to the composition of the forests that the former even withstands the devastation which the Esthonians make in the manufacture of their shoes from its bass. In the hop, the ivy, and the clematis we find here the first representation of the tropical climbers. The smiling green of the meadows alternates with

the gloomy shadows of the forests; and man has taken possession of the earth, restraining the wild vegetation to that absolutely needful for wood and hay, and rich crops reward his industry. We leave this zone of the deciduous woods to scale the rocky barrier of the Alps. Here suddenly appear quite different plants; with the great woods of trees, the coriaceous shining leaves of which last through the mild winter, and round the mighty stems of which climb the vine and flame-colored Bignonias, unite the smaller bushes of myrtle, arbutus, and pistachio. Here and there the dwarf palm is met with; labiate plants and crucifers, and fair-flowered rock-roses replace in summer the spring flora of scented hyacinth and narcissus; but rarely, even in the most favored spots, is the eye dazzled by the brilliancy of evergreen leaves, or the glaring play of color of the naked, jagged mountain chains, gladdened by the mild radiance of verdant meadows. In recompense, mankind has, in this zone of evergreen woods, seized upon the fruit of the Hesperides. It is

“the land where the Citrons blow,
Through the dark-green leaves the gold Oranges glow.”

But onward, ever onward, strives the insatiable son of Iapetus; no legend of African deserts, no death-news of the many adventurous travelers who have gone forth to seek the source of the Niger, frighten him back. On the west coast of Africa, in the Canary Isles, is, indeed, no longer found the gigantic dog, from which, as Pliny told, the islands derived their name, but Flora gives for booty richest treasures

which she, by aid of the tropical sun, has succeeded in extracting from the soil, moistened by the vapors of the ocean. Round sycamores twine mighty cissus stems; capers and baubinsias interlace in the thickets of balsamic shrubs. The slender date-palm soars aloft, and the baobab grows up into gigantic masses of wood. The wondrous cactus-like forms of the leafless spurge, distinguished by their poisonous or pleasant-flavored, sweet milk, as the case may be, betray a peculiar formative power in Nature; and the dragon-tree in the garden of Orotava,* in Teneriffe, a gigantic arborescent lily-plant, recounts to the musing listener the traditions of thousands of years.

Six zones of vegetation have we thus passed through, in which the continually increasing temperature of the climate called forth ever a different, ever a more luxuriant vegetation, and we conclude our wanderings, after a short rest under the five-thousand-year-old Dracænas, by climbing the Pic of Teyde. Man has taken possession of the soil of the plain at its foot and dislodged the original vegetation. Through vineyards and maize-fields we ascend, till the shades of the evergreen bay-laurel surround us. Trees of the lace-bark tribe and similar plants succeed; we wander for a time through a *zone of evergreen forest trees*. At a height of 4,000 feet we lose the plants which had so far accompanied us. A very small number of peculiar plants mark a quickly

* This famous tree was blown down by a storm in 1868. It was believed to have been five or six thousand years old.—E. S.

traversed *zone of deciduous trees*, and we come among the resinous trunks of the Canary pine. A *zone of conifers* shield us from the sun's rays up to a height of 6,000 feet, then the vegetation suddenly becomes low—from humble bushes it passes into a flora which bears all the characters of the Alpine plants, till finally the naked rock sets a limit to all organic life, and no snow and ice bedeck the summit of the mountain, only because its height of 12,236 feet does not, in a position so near the tropics, extend up to the region of eternal snow. Counting by the limits of vegetation, we have resurveyed in a few hours' climb the wide way from Spitzbergen to the Canaries, an extent of more than fifty degrees of latitude.

The plant is dependent on the condition of the soil, in the widest sense of the word, on the store of nutriment it contains, and on all that influences the chemical process of formation, consequently, above all, upon a determinate temperature. The universal, indispensable nutrient substance of plants, and, at the same time, the matter by means of which all the rest are conveyed into it, is water. Without water there is no vegetation. The orchidaceous plants of the tropical forest let their peculiarly constructed roots hang down from the branch to which they cling in the warm, moist atmosphere, and absorb water in the form of vapor. Our water-lilies and the proper bog-plants will only flourish when surrounded by liquid water, or, at least, with their roots dipping in it. The case is quite different with the great majority of plants; they have to extract their nutriment

from the earth, which contains the moisture to be absorbed into them in a peculiar condition. If to these three classes of air, water, and earth-plants we add one more, namely, the true parasites, which, like our dodder, draw their organized nutriment from other plants, we have obtained the principal divisions of stations.

Every soil which bears plants contains also in its composition all the substances required by all plants, only the proportions differ, and the predominance of silex, lime, or common salt must consequently favor especially the growth of grasses, pulses, or shore-plants, although these are by no means exclusively confined to the proper sandy or calcareous soils, or to the seaside. In addition to the chemical conditions, there is yet another which modifies the former and, where it brings about the same actions, contributes to chain particular plants so much the more firmly, exclusively to particular soils, or contrariwise also contributes to conceal or obliterate the connection between plants and the chemical nature of the soil. This consists in the mechanical condition and physical peculiarities of the soil. There are plants which will only settle on unbroken *rocks*, which when the other conditions coincide, spring from these rocks over on to our *walls*, like the Wall Rue Spleenwort,* a little fern, the name of which denotes its station. Others occur only where weathering has broken up the solid rock into small fragments, *drift* plants, which, clinging to mankind, se-

* *Asplenium Ruta muraria*.

lect *rubbish heaps*, which most resemble their natural station; our great nettle and henbane may serve as examples. Lastly, other plants grow only where the rocks have been reduced to fine powder, in *sand* or in the fine-grained *clay* produced by chemical decomposition. The so-called German Sarsaparilla, the sea-reed, is an example of the first condition, but there is no definite condition corresponding to it in the vicinity of human habitations. Clay, on the other hand, stands beside the black substance humus, resulting from the decomposition of organic matter. Both rich in soluble salts, important to vegetation, both distinguished in regard to their property of absorbing from the atmosphere, and thus conveying to the roots of plants gases and aqueous vapor, they cause, singly or in combination, the most luxuriant vegetation. We thus obtain three stages in reference to the qualities of the soil-pure earths, wholly devoid of vegetation; mixed earths, without clay or humus, with an arid but characteristic vegetation; and lastly, soil rich in clay and humus, with the greatest abundance and variety of plants.

Australia has, in common with Europe, a very common plant, the daisy (*Bellis perennis*). The same little flower is found in northern Asia, in some regions in Africa and South America, and where it occurs it climbs the mountains from the level of the sea up to the snow-limit. The little enchanter's nightshade, the delicate Linnæa, the bittersweet, the bird's knot-grass, the blue gentian, the dwarf birch, and the herbaceous willow, and several others, are indigenous both in Europe and North America. The

common self-heal, the duckweed, and our reed grow in New Holland. The bog-moss covers the moors of Peru and New Granada, as well as those of the Hartz and of Dovrefjeld in Norway. The brownish *Parmelia*, which clothes all our walls in Germany, palings, and old trees, is no less present on the only ninety-year-old Yorullo in Mexico. The bluish bristle-grass, which is one of the commonest garden and field weeds on sandy soils with us, grows also in the interior of Brazil on suitable soil. A characteristic plant of the seashores of Northern Europe and the vicinity of salt-springs, *Ruppia maritima*, grows equally on the northern coast of Germany, in Brazil, and the East Indies. But it is needless to accumulate examples, for these so hasten to present themselves that the view finds some support in observation which assumes that every plant must exist in every part of the globe where the known conditions of its vegetation are present.

The little daisy (*Bellis perennis*) exhibits a certain wilfulness. It is wanting all through North America; and that which we tread down as an insignificant weed in our European meadows is there reared with the most tender care in the botanical gardens. If we pass in review the vegetation of different countries, we see that causes appearing similar in our present knowledge of them bring forth indeed *similar*, but by no means the same, forms of plants. To the plants of a particular northern latitude correspond in the analogous height of the Alps, situated southward, other species of the same genera, or other genera of the same family; or

the plants of America are represented in the same latitudes in the Old World by plants which are different, but closely allied, in their development. Nay, even plants which belong to totally different families assume, at least in their outward appearance, similar shapes. Thus the cactus plants of the New World correspond to the leafless, fleshy spurges of the torrid Africa.

If, again, we anticipate that a greater variety of conditions of vegetation is the cause why the variety of vegetation, the number of species of plants, continually augments from the pole toward the equator, and that on the same account the number of sociably growing plants, of species which clothe great tracts in countless individual specimens, also increases in the same measure, we find that we are still far from being enabled to give a scientific account of the matter. It seems to us wholly the result of caprice that particular plants are distributed widely over the globe, while others must live cribbed in the narrowest spot, as, for instance, the *Wulfenia*, occurring exclusively on the Carinthian Alps; that particular families, like the *Compositæ*, flourish abroad over the whole earth, while others, like the peppers and the palms, only occur between very definite degrees of latitude on either side of the equator, the *Proteaceæ* only in the Southern Hemisphere, the cactus tribe only in the western half of our earth. Just as inexplicable is the *mode of distribution* of the families of plants. While the palms diminish in number from the equator into higher latitudes, the *Compositæ* attain their highest development in the zones of mean

temperature, their number of species diminishes from these in both directions, equally toward the equator and toward the poles; while, finally, the grasses increase constantly from the equator toward the poles.

This, to us inexplicable, mode of distribution of plants according to species, genera, families, orders, and classes gives rise to certain peculiar regions on the globe, which are characterized by the predominance of certain forms of plants, or by the exclusive occurrence of particular families. These portions of the earth's surface are called Geographical Regions of Plants, and to them have been applied the names of men who have made themselves especially famous by the investigation of these places.

I have already alluded to the regions of saxifrages and mosses, or Wahlenberg's region, which extends from the eternal snow of the poles, or the summits of the mountains, down to the limit of the growth of trees, and is distinguished by the absence of arborescent plants, and even of the taller shrubs. Adjoining this comes the great Linnæan region, including northern Europe and northern Asia to the great chain of mountains which extends from the Pyrenees to the Alps. Woods of conifers, or deciduous trees, luxuriant meadows, and broad heaths, in Asia the peculiar salt steppes, especially determine the characters of this region, which, at least in its European portion, is now too widely taken possession of to exhibit its natural physiognomy. The wide basin from the Alps to Atlas, the deepest part filled by the Mediterranean Sea, forms a third region, distinguished by the abundance of aromatic Labiate plants, fair,

but fleeting, lily plants, and the resinous rock-roses. The solitary dwarf-palm and balsam-trees denote in this, De Candolle's region, the transition to the tropics. Parallel to the two last-named regions, North America is divided into a northern region named in honor of Michaux, distinguished by peculiar conifers, oaks and walnuts, by innumerable asters and golden-rods from the Linnæan region, and a southern, Pursh's region, in which most strikingly appear the trees with broad shining leaves and large splendid flowers, like the tulip-tree, the magnolia, and others defining the character. Between Kämpfer's region, comprehending China and Japan, Wallich's in the highlands of India, and the Polynesian, or island region of Reinwardt, renowned for its poison-tree and its giant-flower, lies Roxburgh's region, which extends through both the Indian peninsulas, which conceals among the shadows of the monster fig-trees the *Scitamineæ*, or aromatic lilies, like ginger, cardamums, and turmeric, or in little woods of aromatic barks, like the cinnamon and cassia, matures in thick, shapeless stems the starch of the sago. We pass over Blume's region in the mountains of Java, Chamisso's in the Archipelago of the South Sea, and Forster's region in New Zealand, and turn again to Africa, where the desert, Delile's region, ripens, in the oases, the date, and in the tender-leaved acacias concocts the abundance of gum-arabic and senega, which commerce brings to the service of our industry. To this, eastward, adjoins Forskäl's region, where the balsam-trees predominate; on the south, Adanson's, the characteristic plant of which

perpetuates the name of that enlightened botanist, the thousand-year-old giant stem of the *Adansonia digitata*, the baobab, or monkey's-bread. The little known Africa gives only one more region, at its southern extremity, Thunberg's, bedecked with stapelias, mesembryanthemums, brilliant heaths, and evil-scented beeku-shrubs, but poor in woods. New Holland and Van Diemen's Land bear the name of their first and most profound botanical investigator, Robert Brown; and Central and South America distribute their vegetable riches into eight more regions, which are dedicated to Jacquin, Bonpland, Humboldt, Ruiz and Pavon, Swartz, Martius, St. Hilaire, and D'Urville; among these, Jacquin's region is remarkable for its strange cacti; Humboldt's, on the heights of the South American Andes, for its Quinoa forests; and that of Martius, in the interior of Brazil, for its abundance of palms, for its quantity of climbing plants or lianes and parasitic plants.

All over the globe has man, for the supply of necessary food, selected almost solely summer plants, that is, such plants as complete their whole vegetative processes, or, at all events, the development of all the parts containing nutrient matter, within the course of a few months. By this means he has rendered himself independent in the half-tropical regions of the evil action of the dry season, and in the higher latitudes of the destructive influence of cold, and thus ensured the possibility of cultivating plants, which there must be killed by the drought of summer, here by the cold of winter. Setting aside the cultivation of fruits, which serve rather pleasure than necessity,

there remain but three arborescent vegetables in the whole world which can be included among the true food-plants, namely, the bread-fruit, the cocoanut, and the date, which actually furnish the chief proportion of the food of great bodies of men and over widely extended areas, and thence have become objects of culture; the *Cycadaceæ*, and sago-palms, on account of their starchy parenchyma, can at most perhaps be taken into our reckoning only in a very limited circle in the East Indies. All the rest of the food-plants are either such as possess a subterraneous, usually tuberous stem, which sends up shoots above the soil, persisting but a few months, on which develop flowers and fruit, while during the remaining time sleeping, as it were, beneath the protecting coverlet of earth, it sets the disfavor of the climate at defiance, or such as die during or at the end of a short period of vegetation, and ensure the future reproduction in the slumbering germ of the seed. To the former belong, for instance, the potato, derived from the Cordilleras of Chili, Peru, and Mexico; to the latter, almost all our corn-plants.

One plant alone distinguishes itself among the cultivated plants by a peculiar mode of vegetation, a plant which was perhaps the earliest gift of Nature to man awakening to life, and thus the object of the earliest culture; I mean the banana. And this plant was not merely the first, but the most valuable gift of Nature; its slightly aromatic, sweet and nutritive fruits are the sole, or at least the chief, food of the major part of the inhabitants of the hotter regions. A creeping subterraneous root-stock sends out on high,

from lateral buds, a shaft fifteen to twenty feet long, which consists merely of the rolled-up, sheath-like leaf-stalks, bearing the velvet-like glancing leaves, often ten feet long and two feet broad; the midrib of the leaf alone is firm and thick, but the blade of the leaf on either side so delicate that it is readily torn by the wind, whence the leaf acquires a peculiar feathered aspect. Among the leaves presses up the rich cluster of flowers, which within three months after the shoot has arisen forms from 150 to 180 ripe fruits, about the size and form of a cucumber. The fruits weigh altogether about 70 or 80 pounds, and the same space which will bear 1,000 pounds of potatoes brings forth in a much shorter time 44,000 bananas; and if we take account of the nutritious matter which this fruit contains, a surface which, sown with wheat, feeds one man, planted with bananas, affords sustenance to five-and-twenty. Nothing strikes the European landing in a tropical country so much as the little spot of cultivated land round a hut, which shelters a very numerous Indian family.

Not till long after did man learn to know and cultivate the gifts of Ceres. It must, in fact, surprise us, at present, to see that but a few species of a single family of plants furnish the principal food of the greater proportion of mankind, namely, the so-called corn-plants, or *Cerealia*, of the family of grasses. This family includes nearly 4,000 species, and yet not twenty of them are cultivated for the food of man. In their real nature these cultivated grasses are all summer plants, but varieties have been obtained from some of the most important of them, which, in the

proper climate, sown in autumn, germinate and pass the winter under the warm covering of snow, so that they are in a condition to shoot out strongly in the spring, while the soil is being prepared for the other summer plants.

Barley has the widest range of distribution of all the *Cereal*ia, and is cultivated from the extreme limits of culture in Lapland to the heights immediately beneath the equator. But it has by no means the same importance everywhere that it has in the northern region, where, in a little narrow zone, it appears as the sole bread-corn. In Lapland and northern Asia, rye soon appears beside it, but by the inclemency of the climate confined to favorable years, and therefore not properly to be regarded as the principal food. First in Norway, Sweden, Finland, and Russia does the rye become the peculiar bread-corn; and wheat takes its place beside it in the north of Great Britain and Germany, as the rye before joined barley. In the centre of Germany, in the south of Great Britain, in France, and in a wide range toward the East, including the whole of the Caspian Sea, wheat is the prevailing cultivated plant, which in the basin of the Mediterranean and throughout North America is associated with maize. Rice takes the place of the latter in Egypt and in northern India, and holds undisputed rule in the peninsulas of India, in China, Japan, and the East Indian islands, shares it in the west coast of Africa with maize, which, on the other hand, is the exclusively cultivated corn-plant of the greatest part of tropical America, with only some unimportant exceptions. In southern America, Af-

rica, and Australia wheat again enters the field with the decreasing temperature. The culture of *Tef* and *Toccusso* in Abyssinia, of millet in Western Africa and Arabia, as well as of *Eleusine* and millet in the East Indies, are quite of subordinate importance.

Some other plants bear a far more important share in the nutrition of mankind than the grasses last named. Even in the most northern zone of the barley and rye, the buckwheat is an object of tolerably extensive culture. With the already named banana, the yams, the manioc, and the batatas contribute largely to the daily food of the inhabitants of the tropics, of the Old as of the New World, added to which the Andes presents itself a peculiar vegetable, the quinoa, a plant which simultaneously produces edible tubers and abundance of seeds, comparable to those of buckwheat. Lastly, we may not pass over the *Bread-fruit*, in the proper sense of the word, which is the principal food of the inhabitants of the large islands which extend from the East Indies through the whole tropical ocean to the west coast of America, the gift of a large and beautiful tree of the family of the nettle, which from the use it is turned to is called the bread-fruit tree. For the sake of variety, some also cultivate with it the tarroo-root, the *Tacca* tubers, or some ferns, the farinaceous leaf-stalks of which afford a dainty meal. Last of all I will mention the potato, which has spread over the whole earth with such rapidity from the mountains of the New World that in many places it threatens, not exactly to the advantage of mankind, to supplant every other culture.

PHYSIOGNOMY OF PLANTS

—ALEXANDER VON HUMBOLDT

THE carpet of flowers and of verdure spread over the naked crust of our planet is unequally woven; it is thicker where the sun rises high in the ever cloudless heavens and thinner toward the poles, in the less happy climes where returning frosts often destroy the opening buds of spring or the ripening fruits of autumn. Everywhere, however, man finds some plants to minister to his support and enjoyment.

Lichens form the first covering of the naked rock, where afterward lofty forest trees rear their airy summits. The successive growth of mosses, grasses, herbaceous plants and shrubs or bushes, occupies the intervening period of long but undetermined duration. The part which lichens and mosses perform in the northern countries is effected within the tropics by *Portulacas* *Gomphrenas* and other low and succulent shore-plants. The history of the vegetable covering of our planet, and its gradual propagation over the desert crust of the earth, has its epochs as well as that of the migrations of the animal world.

When leaving our oak forests, we traverse the Alps or Pyrenees, and enter Italy or Spain, or when we direct our attention to some of the African shores of the Mediterranean, we might easily be led to draw the erroneous inference that hot countries are marked by the absence of trees. But those who do so, forget that the south of Europe wore a different aspect on the first arrival of Pelasgian or Cartha-

ginian colonies; they forget that an ancient civilization causes the forests to recede more and more, and that the wants and restless activity of large communities of men gradually despoil the face of the earth of the refreshing shades which still rejoice the eye in northern and middle Europe, and which even more than any historic documents prove the recent date and youthful age of our civilization.

The deserts to the south of the Atlas, and the immense plains or steppes of South America, must be regarded as only local phenomena. The latter, the South American steppes, are clothed, in the rainy season at least, with grass and with low-growing, almost herbaceous, mimosas. The African deserts are, indeed, at all seasons, devoid of vegetation; seas of sand, surrounded by forest shores clothed with perpetual verdure. A few scattered fan-palms alone recall to the wanderer's recollection that these awful solitudes belong to the domain of the same animated terrestrial creation which is elsewhere so rich and so varied. The fantastic play of the mirage, occasioned by the effects of radiant heat, sometimes causes these palm trees to appear divided from the ground and hovering above its surface, and sometimes shows their inverted image reflected in strata of air undulating like the waves of the sea. On the west of the great Peruvian chain of the Andes, on the coasts of the Pacific, I have passed entire weeks in traversing similar deserts destitute of water.

When once a region has lost the covering of plants with which it was invested, if the sands are loose and mobile and are destitute of springs, and if the

heated atmosphere, forming constantly ascending currents, prevents precipitation taking place from clouds, thousands of years may elapse ere organic life can pass from the verdant shores to the interior of the sandy sea, and repossess itself of the domain from which it had been banished.

Those, therefore, who can view nature with a comprehensive glance and apart from local phenomena, may see from the poles to the equator organic life and vigor gradually augment with the augmentation of vivifying heat. But, in the course of this progressive increase, there are reserved to each zone its own peculiar beauties; to the tropics, variety and grandeur of vegetable forms; to the north, the aspect of its meadows and green pastures, and the periodic reawakening of nature at the first breath of the mild air of spring. Each zone, besides its own peculiar advantages, has its own distinctive character.

In determining leading forms, or types, on the individual beauty, the distribution, and the grouping of which the physiognomy of the vegetation of a country depends, we must not follow the march of systems of botany, in which from other motives the parts chiefly regarded are the smaller organs of propagation, the flowers and the fruit; we must, on the contrary, consider solely that which by its mass stamps a peculiar character on the total impression produced, or on the aspect of the country. Among the leading forms of vegetation to which I allude, there are, indeed, some which coincide with families belonging to the "natural systems" of botanists.



Herbs, Useful and Medicinal

1, Myrtle; 2, Myrrh; 3, Hemlock; 4, Wormwood; 5, Frankincense; 6, Hyssop

Such are the forms of bananas, palms, *Casuarinæ*, and *Coniferæ*. But the botanic system divides many groups which the physiognomist is obliged to unite.

We will begin with the palms, the loftiest and noblest of all vegetable forms, that to which the prize of beauty has been assigned by the concurrent voice of nations in all ages; for the earliest civilization of mankind belonged to countries bordering on the region of palms, and to parts of Asia where they abound. Their lofty, slender, ringed, and, in some cases, prickly stems terminate in aspiring and shining either fan-like or pinnated foliage. The leaves are frequently curled, like those of some *Gramineæ*. Smooth, polished stems of palms carefully measured by me had attained 192 English feet in height. In receding from the equator and approaching the temperate zone, palms diminish in height and beauty. The indigenous vegetation of Europe only comprises a single representative of this form of plants, the sea-coast dwarf-palm or *Chamærops*, which in Spain and Italy extends as far north as the 44th parallel of latitude. The true climate of palms has a mean annual temperature of $78^{\circ}.2-81^{\circ}.5$ Fahr. The date, which is much inferior in beauty to several other genera, has been brought from Africa to the south of Europe, where it lives, but can scarcely be said to flourish, in a mean temperature not exceeding $59^{\circ}-62^{\circ}.4$ Fahr.

In all parts of the globe the palm form is accompanied by that of plantains or bananas; the *Scitamineæ* and *Musaceæ* of botanists, *Heliconia*, *Amomum*, and *Strelitzia*. In this form, the stems,

which are low, succulent, and almost herbaceous, are surmounted by long, silky, delicately veined leaves of a thin, loose texture, and bright and beautiful verdure. Groves of plantains and bananas form the ornament of moist places in the equatorial regions.

The form of *Malvaceæ* and *Bombaceæ*, represented by *Ceiba*, *Cavanillesia*, and the Mexican hand-tree *Cheirostemon*, has enormously thick trunks; large, soft, woolly leaves, either heart-shaped or indented; and superb flowers, frequently of a purple or crimson hue. It is to this group of plants that the baobab, or monkey bread-tree (*Adansonia digitata*), belongs, which, with a very moderate elevation, has a diameter of 32 English feet, and is probably the largest and most ancient organic monument on our planet. In Italy the *Malvaceæ* already begin to impart to the vegetation a peculiar southern character.

The delicately pinnated foliage of the *Mimosa* form, of which *Acacia*, *Desmanthus*, *Gleditschia*, *Porleria*, and *Tamarindus* are important members, is entirely wanting in our temperate zone in the Old Continent, though found in the United States, where, in corresponding latitudes, vegetation is more varied and vigorous than in Europe. The umbrella-like arrangement of the branches, resembling that seen in the stone-pine in Italy, is very frequent among the *Mimosas*. The deep blue of the tropic sky seen through their finely divided foliage has an extremely picturesque effect.

The heath form belongs more especially to the

African continent and islands. Arborescent heaths, like some other African plants, extend to the northern shores of the Mediterranean; they adorn Italy and the cistus-covered grounds of the south of Spain. In the countries adjoining the Baltic, and further to the north, the aspect of this form of plants is unwelcome as announcing sterility.

The cactus form is almost exclusively American. Sometimes spherical, sometimes articulated or jointed, and sometimes assuming the shape of tall, upright polygonal columns resembling the pipes of an organ, this group presents the most striking contrast to those of Liliaceæ and bananas.

While the above-mentioned plants flourish in deserts almost devoid of vegetation, the Orchideæ enliven the clefts of the wildest rocks and the trunks of tropical trees blackened by excess of heat. This form (to which the vanilla belongs) is distinguished by its bright green succulent leaves, and by its flowers of many colors and strange and curious shape, sometimes resembling that of winged insects, and sometimes that of the birds which are attracted by the perfume of the honey vessels. Such is their number and variety that, to mention only a limited district, the entire life of a painter would be too short for the delineation of all the magnificent Orchideæ which adorn the recesses of the deep valleys of the Andes of Peru.

The Casuarina form, leafless, like almost all species of cactus, consists of trees with branches resembling the stalks of our Equisetums. It is found only in the islands of the Pacific and in India, but

traces of the same singular rather than beautiful type are seen in other parts of the world.

As the banana form shows the greatest expansion, so the greatest contraction of foliage is shown in Casuarinas, and in the form of needle-trees (Coniferae). Pines, thuias, and cypresses belong to this form, which prevails in northern regions, and is comparatively rare within the tropics: in Dammara and Salisburia the leaves, though they may still be termed needle-shaped, are broader. In the colder latitudes, the never-failing verdure of this form of trees cheers the desolate winter landscape, and tells to the inhabitants of those regions that when snow and ice cover the ground the inward life of plants, like the Promethean fire, is never extinct upon our planet.

Like mosses and lichens in our latitudes, and like Orchideae in the tropical zone, plants of the Pothos form clothe parasitically the trunks of aged and decaying forest trees: succulent herbaceous stalks support large leaves, sometimes sagittate, sometimes either digitate or elongate, but always with thick veins. The flowers of the Aroideae are cased in hooded spathes or sheaths, and in some of them when they expand a sensible increase of vital heat is perceived. Stemless, they put forth aerial roots. Pothos, Dracontium, Caladium, and Arum all belong to this form, which prevails chiefly in the tropical world. On the Spanish and Italian shores of the Mediterranean, Arums combine with the succulent Tussilago, the acanthus, and thistles, which are almost arborescent, to indicate the increasing luxuriance of southern vegetation.

Next to the last-mentioned form, of which the Pothos and Arum are representatives, I place a form with which, in the hottest parts of South America, it is frequently associated—that of the tropical twining rope-plants, or Lianes, which display in those regions, in Paullinias, Banisterias, Bignonias, and Passifloras, the utmost vigor of vegetation. It is represented to us in the temperate latitudes by our twining hops and by our grapevines. On the banks of the Orinoco the leafless branches of the Bauhinias are often between 40 and 50 feet long; sometimes they hang down perpendicularly from the high top of the Swietenia, and sometimes they are stretched obliquely like the cordage of a ship; the tiger-cats climb up and descend by them with wonderful agility.

In strong contrast with the extreme flexibility and fresh, light-colored verdure of the climbing plants, of which we have just been speaking, are the rigid, self-supporting growth and bluish hue of the form of the Aloes, which, instead of plaint stems and branches of enormous length, are either without stems altogether or have branchless stems. The leaves, which are succulent, thick, and fleshy, and terminate in long points, radiate from a centre and form a closely crowded tuft. The tall-stemmed aloes are not found in close clusters or thickets like other social or gregarious plants or trees; they stand singly in arid plains, and impart thereby to the tropical regions in which they are found a peculiar, melancholy, and I would almost venture to call it, African character. Taking for our guides resem-

blance in physiognomy, and influence on the impression produced by the landscape, we place together under the head of the Aloe form (from among the Bromeliaceæ), the Pitcairnia, which in the chain of the Andes grow out of clefts in the rocks; the great *Pourretia pyramidata* (the *Atschupalla* of the elevated plains of New Granada); the American Aloe (*Agave*); *Bromelia aranas* and *Bromelia karatas*; from among the Euphorbiaceæ the rare species which have thick, short candelabra-like divided stems; from the family of Asphodeleæ the African Aloe and the Dragon tree (*Dracæna draco*); and lastly, from among the Liliaceæ, the tall, flowering *Yucca*.

If the Aloe form is characterized by an almost mournful repose and immobility, the form of Gramineæ, especially the physiognomy of aborescent grasses, is characterized, on the contrary, by an expression of cheerfulness and of airy grace and tremulous lightness, combined with lofty stature. Both in the East and West Indies groves of bamboo form shaded overarching walks or avenues. The smooth, polished and often lightly waving and bending stems of these tropical grasses are taller than our alders and oaks. The form of Gramineæ begins even in Italy, in the *Arundo donax*, to rise from the ground and to determine by height as well as mass the natural character and aspect of the country.

The form of ferns, as well as that of grasses, becomes ennobled in the hotter parts of the globe. Arborescent ferns, when they reach a height of above forty feet, have something of a palm-like appear-

ance; but their stems are less slender, shorter, and more rough and scaly than those of palms. Their foliage is more delicate, of a thinner and more transparent texture, and the minutely indented margins of the fronds are finely and sharply cut. Tree ferns belong almost entirely to the tropical zone, but in that zone they seek by preference the more tempered heat of a moderate elevation above the level of the sea, and mountains two or three thousand feet high may be regarded as their principal seat. In South America the arborescent ferns are usually associated with the tree which has conferred such benefits on mankind by its fever-healing bark. Both indicate by their presence the happy region where reigns a soft, perpetual spring.

I will next name the form of Liliaceous plants (*Amaryllis*, *Ixia*, *Gladiolus*, *Pancratium*), with their flag-like leaves and superb blossoms, of which southern Africa is the principal country; also the willow form, which is indigenous in all parts of the globe, and is represented in the elevated plains of Quito (not in the shape of the leaves, but in that of the ramification), by *Schinus Molle*; *Myrtaceæ* (*Metrosideros*, *Eucalyptus*, *Escallonia myrtilloides*); *Melastomaceæ*, and the laurel form.

It is under the burning rays of a tropical sun that vegetation displays its most majestic forms. In the cold north the bark of trees is covered with lichens and mosses, while between the tropics the *Cymbidium* and fragrant vanilla enliven the trunks of the *Anacardia* and of the gigantic fig trees. The fresh verdure of the *Pothos* leaves and of the *Dracontia*

contrasts with the many colored flowers of the Orchideæ; Climbing Bauhinias, Passifloras, and yellow flowering Banisterias twine round the trunks of the forest trees. Delicate blossoms spring from the roots of the Theobroma, and from the thick and rough bark of the Crescentias and the Gustavia. In the midst of this profusion of flowers and fruits, and in the luxuriant intertwinings of the climbing plants, the naturalist often finds it difficult to discover to which stem the different leaves and flowers really belong. A single tree adorned with Paullinias, Bigonias, and Dendrobium forms a group of plants which, if disentangled and separated, would cover a considerable space of ground.

In the tropics vegetation is generally of a fresher verdure, more luxuriant and succulent, and adorned with larger and more shining leaves than in our northern climates. The "social" plants, which often impart so uniform and monotonous a character to European countries, are almost entirely absent in the equatorial regions. Trees almost as lofty as our oaks are adorned with flowers as large and as beautiful as our lilies. On the shady banks of the Rio Magdalena in South America, there grows a climbing Aristolochia bearing flowers four feet in circumference which the Indian boys draw over their heads in sport, and wear as hats or helmets. In the islands of the Indian Archipelago the flower of the Rafflesia is nearly three feet in diameter, and weighs above fourteen pounds.

THE GENESIS OF FLOWERS

—ALEXANDER S. WILSON

THE flowers most generally known are brightly colored flowers adapted for insect fertilization; only these require to attract insects, which is the end served by the perfume and conspicuous coloring. Very many plants, however, bear blossoms so small and obscurely colored that they are either entirely overlooked or not reckoned as flowers at all. The wind-fertilized flowers of the dock and nettle have no occasion for the services of insects, and are destitute of honey, odor, and brilliant petals. Still more insignificant in appearance are the little self-fertilizing cleistogamic flowers, which, toward the end of the season, are produced on the dog-violet. All three kinds possess stamens and pistils, and are therefore recognized as flowers by botanists. Besides stamens and pistils, which are the essential organs of a flower, petals and sepals are usually present. The petals collectively compose the corolla, the sepals the calyx; both together being spoken of as the floral envelopes or perianth. Occasionally, as in the ash, the flower is reduced to its essential organs, the floral envelopes being absent. Plants bearing flowers, whether with or without floral envelopes, are designated phanerogams or flowering plants; they constitute the highest division of the vegetable kingdom. Ferns and mosses, again, are examples of the cryptogamic or flowerless class; they never bear flowers or seeds, but are propagated by minute re-

productive bodies termed spores. This class is divided into thallophytes and vascular cryptogams. The organization of a thallophyte is very simple; the plant body of a fungus or sea-weed, for example, consists entirely of similar cells, and externally shows no distinction into root, stem, and leaf. The structure of a vascular cryptogam, such as a club-moss, horse-tail, or fern, is more complicated; both cells and vessels enter into the composition of its tissues, and externally the distinction of stem and leaf is apparent. Phanerogams also admit of a twofold division into gymnosperms and angiosperms; conifers, cycads, and yews are gymnospermous, having naked seeds, exposed either on the ends of branches or on the surface of open scales. All ordinary flowering plants produce their seed in the interior of a closed ovary, as the lower part of the pistil is called; from this peculiarity they are termed angiosperms.

Only the remains of thallophytes have hitherto been discovered in the oldest Palæozoic rocks. Vascular cryptogams appear in the Silurian strata, attain their maximum in the Carboniferous age, and in succeeding formations are gradually displaced by gymnosperms. The latter occur as early as the Devonian period, but the prevailing type of vegetation down to the close of Palæozoic time continued to be cryptogamic. Angiosperms possibly existed as far back as the Permian times, but it is only in the chalk that their remains begin to be abundant; the vast majority of Mesozoic plants seem to have belonged to the gymnospermous type. Plants with con-

spicuous flowers only date from Tertiary times; they increase in number and importance as we approach the present day.

Although the plants entombed in the rocks are only an inconsiderable fraction of the numbers that formerly existed, the general succession just indicated is fully made out, and as the palæontological evidence accumulates it tends more and more to establish the view that colored blossoms are, geologically speaking, of comparatively recent origin. The vegetation of the earlier geological epochs was marked by a singular uniformity of character; not only were there fewer species than now, and these widely distributed over the globe, but the monotonous green of Palæozoic and Mesozoic forests was unrelieved by gay blossoms such as adorn our fields and orchards. We are indebted to geology for another important fact; fossil plants occur which have no near relatives in the existing flora. Intermediate forms which can not properly be classified with any living family are met with; in others the characters of several modern groups are blended. Although these generalized forms rather upset our systems of classification, they have an important bearing on the origin of living plants. But what a different aspect, when the coal plants were growing in primeval luxuriance, the landscape must have worn from that on which we are accustomed to look! Odd, uncouth lepidodendra of arborescent growth, huge reed-like calamites, gigantic ferns stretched in interminable forests, clothed in one unvaried tint of sombre green. How different is the scene which

nature now presents!—mountains glowing with the purple bloom of heather; hillsides where the furze has spread its cloth of gold; meadows bright with daisies, ranunculi, and cuckoo-flowers; banks where the wild thyme and bluebell grow! The contrast affords a hint of the transformation in our world effected by the introduction of flowers.

Our knowledge may not enable us to describe all the minute steps which led to this remarkable change, but we can at least indicate with great probability the nature of the process and some of the agencies which contributed to bring about this result. To suppose that each species of plant was independently created as we now see it, implies not one creation merely, but many successive creations; moreover, it leaves unexplained all the curious affinities which exist among the members of the vegetable kingdom. The gradations of structure, the geological succession, and the peculiarities of plant growth are much more intelligible when we view the plants which now inhabit the earth as the lineal descendants of those which lived during the earlier ages of geology. From the nature of the case, the theory of development does not admit of actual demonstration; still the evidence in support of it is such that its advocates are entitled to claim a verdict on the mass of indirect and circumstantial evidence.

Among palæozoic cryptogams, we have evidence of the existence of structures which, with comparatively little modification, might be converted into what we now regard as flowers. The abundant remains of lepidodendra in the Coal-measures testify to

the important place attained by the group of lycopods, or club mosses, in the Palæozoic flora. To this family might very well have belonged the archetype from which our modern blossom-bearing plants have come. Our knowledge of this group is derived both from fossil remains and from forms still extant. The selaginellas, so commonly cultivated in greenhouses, are examples; also the little club moss (*Lycopodium selaginodes*) of our highland moors. The last mentioned, though a diminutive form, possesses special interest, being one of the vascular cryptogams which produce two kinds of spores. This heterosporous character was, however, a common feature of extinct lycopods; both large and small spores have been detected in great numbers in coal.

The internal anatomy of the Lycopodiaceæ is somewhat complex, but their external organization is simple. A club moss consists of a cylindrical stem covered with overlapping leaves, spirally arranged, of small size relatively to the stem, and always simple or undivided. The stem branches in a peculiar forked manner, which gives the plant its characteristic candelabra-like form. Existing lycopods are creeping plants, seldom exceeding two feet in height, but many extinct species attained the dimensions of large trees. On the ends of certain branches the leaves are crowded together, giving the terminal portion of each shoot some resemblance to a pine-cone. The crowded leaves on this portion bear, on their upper surfaces, little sacs called sporangia. Certain of these sacs contain very numerous small, rounded bodies, the microspores; others have fewer

spores of larger size, distinguished as macrospores. Sacs containing the small male spores are termed microsporangia; those having the large female spores, macrosporangia. When ripe, a sporangium bursts and discharges its spores, which are scattered by the wind. Should a spore alight on a favorable spot, it germinates after a time and gives rise to a structure called a prothallus, which is really an independent plant. This stage in the life-history of a cryptogam is, however, much better seen in ferns, where the prothallus is entirely expelled from the spore and attains a higher degree of independent development. The prothallus throws out root-hairs, nourishes itself and grows, but the leaf-like form it assumes bears not the remotest resemblance to the parent fern from which it sprang. This phenomenon, characteristic of the higher cryptogams, is known as the "alternation of generations," or "alternate generations." Similar phases are observed in certain animals, the medusæ or jelly fishes, for example. In the course of its development, a fern passes through two distinct phases; first, the spore-bearing stage or sporophyte, represented by the fern frond; second, the egg-bearing stage, the oöphyte or prothallus. As we ascend in the scale of vegetable life, the egg-bearing or sexual generation diminishes in importance, while the sporophyte preponderates more and more. In club mosses, the prothallus has all but lost its independence; in the case of the selaginella it is formed almost entirely within the spore, only a small part being extruded when the spore ruptures. Some of the lycopods are inosporous

—that is, they have, like the ferns, but one kind of spore. Where this is the case, the prothallus developed from the spore bears two sets of sexual organs; the prothallus of one of the heterosporous cryptogams, on the other hand, produces sexual organs of one kind only. Antheridia appear on the prothallus developed from a small spore; archegonia on that from a large one. The former are the male organs, and from them are emitted numerous antherozoids, minute ciliated bodies, which swarm over damp surfaces in all directions. The archegonia are microscopic flasks, each containing an egg-cell or oösphere; they are entered by one or more of the locomotive antherozoids, which coalesce with the egg-cell; the latter is thereby fertilized, and soon grows by cell division into a plant resembling that from which the spores were originally obtained. The life-history of a vascular cryptogam is, so to speak, a story completed in two volumes.

Microscopic research has revealed a most interesting relationship between flowering plants and the heterosporous cryptogams. When the development of a pollen grain in the anther of an ordinary flower is studied and compared with that of a microspore, the two are found to agree in a remarkable manner. The sporangium corresponds in all essential points with the pollen-sac, and its generative tissue develops in similar fashion to that from which the pollen grains originate. In both cases an archesporium is produced by the division of a hypodermal cell; this tissue next divides into a tapetal layer and a row of mother-cells; the tapetal layer dis-

solves, isolating the mother-cells, each of which then forms in its interior four daughter-cells, which are the spores or pollen grains, as the case may be. Not only are the antecedents of microspores and pollen grains alike, but their subsequent histories offer many points of resemblance. Pollen grains are known in numerous instances to form in their interior one or more vegetative cells, which can hardly be regarded as other than a rudimentary male prothallus, such as is commonly developed by a microspore.

There is another bond of connection between flowering and flowerless plants of equal or even greater importance. In the interior of the ovule, or young seed, both of angiosperms and gymnosperms, a special cell is developed, called the embryo-sac. When the history of this cell is traced back, its development is found to be exactly that of a spore. Certain structures are also formed in its interior bearing the closest analogy to the internal prothallus observed in the macrospore of selaginella. These are most obvious in the embryo-sacs of gymnosperms, where the prothallus is represented by the endosperm, while the corpuscula, or secondary embryo-sacs—arising on this are the undoubted equivalents of the archegonia of ferns and other cryptogams. The gymnosperms thus stand midway between vascular cryptogams and angiosperms; but even within the embryo-sac of the latter, in the so-called antipodal cells, may still be detected vestiges of the oöphyte or sexual generation, that structure so characteristic of the flowerless class. An alternation of generations can

thus be traced throughout the greater part of the vegetable kingdom, from the lowest scale mosses through the urn mosses, ferns, horsetails, lycopods, and conifers up to the highest members of the phanerogamic division. But of more importance for our present purpose is the certain identification of the pollen grain and embryo-sac of flowering plants with the microspore and macrospore of the older cryptogams. The stamen of a flower turns out to be simply a peculiar form of microsporangium, while the ovule is a macrosporangium, containing but one macrospore, or occasionally developing several. It follows, therefore, that we have only to enlarge our conception sufficiently to see in the spore-bearing cones of the lycopods structures of essentially the same nature as flowers. All the materials that go to the making of a flower could thus have been furnished by the flowerless flora of Palæozoic ages.

An important change, which marked the transition from cryptogams to flowering plants, must now be mentioned, and to this the animal kingdom furnishes a striking analogy. The lowest vertebrates, such as fishes, are oviparous; the ova are discharged and afterward incubated. Mammals, on the other hand, are viviparous; the young are hatched within the body of the parent. The young of the kangaroo and other marsupials, which constitute the lowest order of mammals, are still very immature at birth. Analagous conditions are found among plants. Cryptogams are all oviparous; the macrospore, which may be regarded as the ovum or egg, separates from the parent plant before fertilization. Phan-

erogams, on the other hand, may be described as viviparous, since they retain the macrospore or ovum until it has developed an embryo. The presence of an embryo constitutes the distinction between a seed and a spore. Unless an embryo be present a seed can not germinate, since germination is simply the emergence of the embryo from the coats of the seed. An extreme case of this retention is seen in the mangrove, where the seed germinates while still attached to the tree; the embryo sends down its long radicle into the mud, and only quits its hold of the parent when it has become firmly established. Orchids and many parasitic plants have seeds with exceedingly minute and imperfect embryos, recalling the undeveloped offspring of the marsupials.

The retention of the egg is attended with a manifest advantage; plainly the viviparous method of reproduction, which obtains in the higher divisions of the two organic kingdoms, is much more economical than the other. By the change to the viviparous condition, several structures present in the cryptogams are rendered useless, and a disused organ invariably degenerates; the prothallus and its adjuncts, having no longer any function to perform, must inevitably begin to atrophy. The rudimentary structures appearing in the embryo-sac of phanerogams can in this way be accounted for. The life-history of a cryptogam extends, as we have seen, to two volumes; it now appears that the life-history of a phanerogam is a second edition of the same story, somewhat abridged and completed in a single volume.

The life-history of certain ferns occasionally undergoes a corresponding abbreviation. In the phenomena of apospory and apogamy we have departures from the ordinary course of development, closely akin to what would be required for the conversion of a cryptogam into a phanerogam. Apospory occurs when the production of spores is omitted, the prothallus growing immediately on the fern frond; apogamy, when the female organs are not developed, and the frond is formed by vegetative growth directly from the prothallus.

There is another fact of which account must be taken. In different groups of plants, in proportion to the complexity of their organization, the female cell tends to increase in size and importance. This is probably accompanied by a chemical or physiological enrichment of the substance of the egg-cell, rendering a higher degree of protection desirable. The inclosure of the embryo-sac within the ovule becomes in these circumstances an advantage. But by this investment, and by the ovule remaining attached to the parent plant, the microspore is of necessity reduced to the condition of a parasite, and the conversion of the male prothallus into a pollen tube becomes intelligible as a case of degeneration.

The closed seed-vessel of angiosperms, there can be little doubt, has in like manner been acquired for the purpose of excluding fungous spores, bacteria, and other destructive germs from the ovules. Van Tieghem found that when the pistil of a flower was opened the ovules could not be directly fertilized, but were invariably attacked by bacteria. The

resinous secretions of conifers act as a germicide, rendering less essential the protection of the seeds, which is the rôle of the pistil in angiosperms.

The gradations between stamens, petals and sepals seen in the water-lily, and the conversion of stamens into petals in the garden rose, suggest a possible variation which would explain the first appearance of the floral envelopes. The nectary may not improbably be a transformed water gland, turned to account as an attraction to visitors, and so of use in promoting cross-fertilization. Every new character tending directly or indirectly to secure this advantage would be perpetuated; the colors, perfumes, mechanism, and most of the peculiarities of flowers become intelligible when viewed as results due to the selective agency of insects.

LIFE HISTORY OF PLANTS

—E. W. PREVOST

THE plant possesses a distinct set of organs capable of absorbing mineral food dissolved in water, and there are also means whereby oxygen and carbonic acid gas can be inspired and transformed into tissue. The young sprout, being at first incapable of seeking for its food, is dependent on its seed for its supplies, consisting of two distinct substances—nitrogenous or albuminous matter, and oil and starchy matters. These two last might have been classed separately, but it is unnecessary here to draw any distinction between them, for it appears that the oil is, during germination, for the most part con-

verted into starch. The effect of moisture and warmth causes the seed to sprout, throw out a stem and root, but these being but feeble must be supplied with food ready prepared, and it is under the influence of the oxygen which obtains access to the seed that a small portion of the albuminous matters contained in the seed is altered, and the products act as a ferment which attacks the insoluble starch, converting it into a sugar that can pass with the water always present into the small sprout; when there it becomes again insoluble, and adds to the structure of the rapidly increasing seedling. The first part of this change, such as the starch has undergone, is well exemplified in the malting of barley, which, after its removal from the malt-house, contains a large amount of "glucose," a kind of sugar which is recognized readily by the taste. The transformation of a portion of the albuminous matter into a ferment not only results in the conversion of starch into sugar, but at the same time the remainder of the albuminoids are rendered soluble and without any change in their composition; they can then accompany the glucose during its passage into the seedling. We see then that the seed is a storehouse for the young plant, providing nourishment until it is strong enough to send down roots into the earth, and put out leaves into the air to seek out food for itself. When the plant becomes strong, and is no longer dependent on the seed for its food, the chemical processes which take place are still more wonderful; now some of the new substances are formed, or why the absence of some one ingredient of the soil (generally present in very

small quantities) should produce certain well-known results, is still unknown. From the soil and by the roots are derived the mineral matters and the nitrogen; the latter in the form of nitrates, which in the plant are completely changed in character, being no longer a combination of nitric acid with a base, but the base has been separated, and the nitrogen of the acid, combined with sulphur, hydrogen, and oxygen, is deposited in the new form of albumenoid matter, which is insoluble in water; but being insoluble, and deposited in the minute cells of the plant, it would appear impossible that it could migrate from one part to another, and this would be the case if no other substance were present; but phosphate of potassium is absorbed by the plant, and this coming in contact with the albumenoids renders them soluble; they can now pass through the cell-walls of the stem, and upward into the seed, where they are stored for future use. Phosphates are also necessary for the production of certain fats, of which they form a part, for the fat of the horse-chestnut and oak contains a small percentage of phosphorus. Of the other salts sucked up by the roots, the sulphate of lime is worthy of mention, as it is necessary to the formation of albumenoids, sulphur being an essential ingredient of these matters, whereas phosphorus is not; and also many essential oils require this element in their composition, and it is to its presence that the oils of black mustard and garlic owe their peculiar pungency.

The function which many of the other ingredients found in the ashes of plants perform is still somewhat uncertain, but all experiments indicate that potash,

lime, and magnesia (the alkaline earths, as these last two are termed) are indispensable to the life of the plant, and that the absence of iron is accompanied by abnormalities of growth. When a soil contains no iron, and this does not occur naturally, the foliage loses its green color, the loss being due to the non-formation of chlorophyl, or the green coloring matter, and where this is absent, the process of assimilation as performed by the leaves ceases, and therefore the plant is in an unhealthy condition; when we come to speak of the respiration and assimilation of plants, an explanation of these terms will be given, but at present a few words on the use of potash, soda, and silica will not be out of place; but we will not attempt to dilate on the uses of other ash ingredients, such as chlorine, for, as before stated, there is no accurate information concerning them, but that they are requisite is certain, while what their functions may be is uncertain.

For general purposes, the chemist considers that the alkalies, potash and soda, are interchangeable, that what soda will do so will potash, and as the former is the cheaper, it is therefore more generally employed. Plants, however, detect a difference, for we find both soda and potash present in their ash in varying quantities, and neither of them entirely absent, so that each must have a distinct part to play; still, to a certain extent, they are interchangeable, for cultivation greatly alters the proportions in which they are present, and this alteration is very marked in the case of the asparagus, which when growing wild contains equal quantities of these bases, but by

cultivation nearly the whole of the soda disappears, while the potash increases nearly threefold. Silica or sand is to be found in every soil, either in the free or combined state, and hence we might suppose that it was indispensable, and certainly it exists in every plant in large proportions, more especially in the hard outer parts, the straw and stems containing a very large quantity of this substance, which is generally considered to be necessary for their rigidity. There are some very remarkable instances known in which deposits of silica are found in plants. Very notable is that occurring in the joints of the bamboo, resembling opal, and bearing the same *tabasheer*; but yet, though silica exists universally in plants, its absence (under artificial conditions) does not seem to prevent their full development.

The alkaline earths, as well as potash, seem to be necessary for the formation of the various salts, such as the oxalate of lime in the leaves of beet and in the common rhubarb, or the oxalate of potash in the wood sorrel. These bases are introduced in the form of nitrate and sulphate or phosphate, but in the plant they separate from the acid, and combine with new acids, which are elaborated through the agency of the leaves.

Having glanced at the functions performed by the mineral constituents, we will pass on to those of the leaves, and here as before no attempt will be made to answer the question, How do the leaves act? but rather our intention is to show the result of their action. The leaves are the means whereby the plant communicates with the air, absorbing from it that portion

which is injurious to the life of animals, namely, carbonic acid gas, which consists of carbon and oxygen; under the influence of sunlight these two components are separated in the leaf, the one from the other, the carbon or solid part remaining in the plant to form all the various compounds, such as starch, oil, and acids, while the oxygen is exhaled into the air for the use of animals; this retention of carbon and conversion into starch, etc., has been termed assimilation, to which we have already referred; now we can appreciate the immense importance of plants of all kinds, for without their aid the atmosphere would become so overburdened with the harmful carbonic acid that it would no longer support life or combustion. A small experiment will readily demonstrate the action of leaves on carbonic acid: if a green laurel-leaf, immersed in a glassful of spring-water, be exposed to sunlight, a number of small bubbles will soon be noticed on the surface of the leaf. In a short time they will increase in size, and finally float to the surface, when by proper means they can be collected and shown to consist of oxygen, which possesses the property of causing a glowing splinter of wood to burst into flame when introduced into it. This oxygen has been produced by the decomposition of the carbonic acid dissolved in the water. It would be incorrect to suppose that the leaves absorb no oxygen, but always give it out, for at all times a proportion of oxygen is inspired, and in the dark, carbonic acid is exhaled, yet the quantity is always less than that of the oxygen exhaled during the day, and at low temperatures the amount of oxy-

gen absorbed exceeds that of the carbonic acid. How to account for the production of starch from the materials at the disposal of the plant is somewhat difficult; but, theoretically, six volumes of carbonic acid combining with five volumes of water produce starch, six volumes of oxygen being liberated; but when once the starch is produced, we know, from laboratory experiments, that sugar can easily be produced from it as well as oxalic acid, etc. The purpose of the leaves is not only to collect air food, but also to get rid of superfluous water, for the roots are continually pumping in water laden with mineral food, so that to allow of the circulation and deposition of this food the water must be got rid of. This water is exhaled from the leaves in the form of invisible vapor, but the quantity depends on the state of the atmosphere, which when moist almost wholly prevents exhalation; on the other hand, in very dry weather, exhalation takes place too rapidly, and the plant withers. Light exerts also a very great influence; the stronger the light the greater is the amount of water exhaled, and, generally speaking, the maximum occurs shortly after midday. During hot and dry weather a grass plant has been known to exhale its own weight in water during the twenty-four hours. From what has been now said, it will be seen how necessary are plants to animals, and animals to plants, as without the one the other would not long survive; for when the atmosphere became exhausted of carbonic acid, which is formed by animals, the plants would have no means of building up starch, etc. The great difference between plants and animals should

also be noted, that whereas the plant is continually feeding only to increase and store up material, the animal feeds to increase and repair the waste that is continually proceeding.

LIFE-FORMS OF PLANTS

—EDWARD CLODD

IF the life-forms of the past somewhat baffle us by their scantiness and imperfectness, those of the present embarrass us by their abundance. But although the existing species of plants and animals are numbered by hundreds of thousands, and the tale is not yet complete, they are classified into a few primary divisions or sub-kingdoms, representing certain allied types, of which the several species included in each sub-kingdom are modified forms. For example, flies and lobsters, beetles and crabs, are grouped in the sub-kingdom of the *Annulosa*, because they are alike composed of distinct segments; boys and frogs, pigs and herrings, are grouped in the sub-kingdom of the *Vertebrata*, because they alike possess an internal bony skeleton, the most important feature of which is the spine or vertebral column. And this classification is applicable alike to past and present organism, there being throughout the whole series of fossil remains no form, however unlike any existing living thing, that is not to be placed in one or other of the sub-kingdoms.

Moreover, a fundamental unity underlies and pervades the whole, a unity of material, of form, and of

function, the differences between organisms, from the slime of a stagnant ditch to the most complex animal, being in degree and in kind. Therefore, although each genus, nay, in most cases, each species, needs for its complete study the labor of a lifetime, it suffices for the majority of us, grateful for the results which the zeal of specialists has achieved, to acquaint ourselves with the essential characteristics which mark the main division of the twin sciences of *Botany* and *Zoology*. Not only is this the only possible thing for us; it is the one thing needful for all, specialists and non-specialists, otherwise the significance of facts, in their relation and dependence, is missed; the larger generalizations are swamped in a sea of detail; we can not, as the phrase goes, see the wood for the trees.

In the old definition of the three kingdoms of nature, the mineral, the vegetable, and the animal, we were taught that plants grow and live, while animals grow, live, and move. But this no longer holds good, at least in respect of the lower forms. There are locomotive plants and animals that are stationary.

The swarm-cells or zoospores which are expelled from some of the lower plants, as algæ and certain fungi, behave like animals, darting through the water by the aid of hair-like filaments called vibratile cilia, finally settling down and growing into new plants; others, as diatoms and desmids, are locomotive throughout life; certain marine animals, as sponges and corals, are rooted to the spot where they grow; while there are organisms which appear

to be plants at one stage of their growth, and animals at another stage.

Other marks of supposed unlikeness have vanished. It was formerly held that among the distinctive features of animals are (1) a sac or cavity in which to receive and digest food; (2) the power to absorb oxygen and exhale carbonic acid; and (3) a nervous system. But although nearly all animals, in virtue of their food being solid, have a mouth and an alimentary cavity, there are certain forms without them, and although plants, in virtue of their food being liquid or gaseous, need not have that cavity, there are plants that have it. Not only is the process of digestion apparent in the leaves of carnivorous plants, but embryonic forms have been found to secrete a ferment similar to the ferment in the pancreatic secretion of animals, and by which they dissolve and utilize the food-stores in their seedlobes as completely as food is digested in our stomachs. And although green plants, under the action of light, break up carbonic acid and release the oxygen, they do the reverse in the dark, as also in respiration; while the quasi-animal fungi, which are independent of light, absorb oxygen and give off carbonic acid.

In the "irritability" of the sundew, Venus's fly-trap, and other sensitive plants, still more so in subtile and hidden movements in plant-cells, we have actions corresponding to those called "reflex" in animals, as the contraction of the shapeless *amœba* when touched, or the involuntary closing of our eyelid when the eye is threatened, or the drawing back of

one's feet when tickled. The filament in the amœba which transmits the impulsions, causing it to contract differs only in one degree from the sensory nerves in ourselves which transmit the impression to the motor nerves, causing the muscles to act; and since there is every reason for referring the contractile actions of plants—*i. e.*, their movements in obedience to stimulus—to like causes, the germs of a nervous system must be conceded to them. The minute observations of Mr. Darwin and his son into the large class of quasi-animal movements common to well-nigh all vegetable life go far to confirm this. The highly sensitive tip of the slowly revolving root, in directing the movements of the adjoining parts, transmitting sensation from cell to cell, "acts like the brain of one of the lower animals; the brain being seated within the anterior end of the body, receiving impressions from the sense organs and directing the several movements."

In these and kindred vital processes, in the so-called sleep of leaves, and the opening and closing of flowers, both regulated by the amount of light, apparently acting on them as it acts on our nervous system; in the detection of subtle differences in light, which escape the human eye, by plants; in their general sensitiveness to external influences, even in the diseases which attack them, the study of which Sir James Paget has commended to pathologists, we have the rudiments of attributes and powers which reach their full development in the higher animals, and therefore a series of fundamental correspondences between plant and animal which point

to the merging of their apparent differences in one community of origin.

In fine, that which was once thought special to one is found to be common to both, and to this there is no exception. Not only is there correspondence in external form in the lower life groups, but, fundamentally, plants and animals are alike in internal structure and in the discharge of the mysterious process of nutrition (although this forms a convenient line of separation) and of reproduction. All, from the lowest to the highest, have their unity and kinship in ancestral life which was neither plant nor animal.

Of course, the difficulty of classifying vanishes in the higher forms; the lowest plants are allied to the lowest animals, but the higher the plant the more it diverges from the animal, which is evidence that in the succession of life the highest plants do not pass into the lower animals. Descent is not lineal, but lateral; the relations between the two kingdoms are represented by two lines starting from a common point and spreading in different directions. Even the "lower" and "higher" are relative terms; the organization of the *amœba* is as complete for its purpose, as is that of the man for his purpose, the modification in the complex forms being due to the division of functions which are performed in every part by the simple forms.

Although the foregoing and numberless other facts, together with the law of continuity, alike forbid the drawing of any hard and fast lines, and involve the conclusion, to borrow Professor Huxley's words,

"that the difference between animal and plant is one of degree rather than of kind, and that the problem whether, in a given case, an organism is an animal or a plant may be essentially insoluble," there exists, exceptions notwithstanding, a broad distinction in the mode of nutrition.

"All things the world which fill
Of but one stuff are spun,"

and this stuff, the basis of all life, the formative power, is a semi-fluid, sticky material, full of numberless minute granules in ceaseless and rapid motion, to which the name "protoplasm" (Gr. *protos*, first; *plasma*, formed) has been given. It consists of four of the elementary substances, carbon, hydrogen, oxygen, and nitrogen, complexly united in the compound called *protein*, which is closely identical with the albumen or white of an egg. These are the *essential* elements, but a few others enter into the chemistry of life, with slight resulting differences in the *incidental* elements in animals and plants. As water is necessary to all vital processes, a very large proportion enters into living matter.

But there is this fundamental and significant difference between the two kingdoms. The plant possesses the mysterious power of weaving the visible out of the invisible; of converting the lifeless into the living. This it does in virtue of the chlorophyll, or green coloring matter, which is found united with definite portions of the protoplasm-mass, of which it is a modification, the exact nature being unknown. The water and the carbonic acid which the plant ab-

sorbs through the numberless stomata or mouth-pores in its leaves or integument are, when the sunlight falls upon them, broken up by the chlorophyll, which sets free the oxygen, and locks together the hydrogen and carbon, converting this hydro-carbon into the simple and complex cells and tissues of the plant, with their store of energy for service to itself and other organisms. Animals, a few low forms excepted, can not do this; they are powerless to convert water, salts, gases, or any other inorganic substances, into organic; they are able only to assimilate the matter thus supplied by the plant, nourishing themselves therewith either directly, by eating the plant, or indirectly, by eating some plant-feeding animal.

In other words, the plant manufactures protein from the mineral world, and the animal obtains the protein ready-made; the plant converts the simple into the complex; and this the animal, by combining it with oxygen, consumes, using up the energy it thereby obtains in doing work. So the plant is the origin of all the energy possessed by living things, but why it can by virtue of the sunshine convert the stable inorganic into the unstable organic, while the animal can not, we do not know. Neither do we know whether plant preceded animal, or *vice versâ*, in life's beginnings, although the evidence seems to point in favor of the priority of the plant. Structurally the lowest animal is below the lowest plant, since it is a speck of formless, colorless protoplasm, whereas the protoplasm of the lowest plant is organized to the extent that it has formed for

itself an outer layer or membraneous coat called the cell-wall. For example, the vegetable character of yeast-granules is determined, apart from their mode of nutrition, by the protoplasm being inclosed within a cellulose coat, and the animal character of the *amœba*, not because of contractile or locomotive power or of inability to manufacture protein from inorganic matter, but by the absence of any such covering. Upon this Haeckel remarks that the vegetable cells sealed their fate when inclosed within a hard thick cellular shell, being thereby less accessible to external influence, and less able to combine for the construction of nervous and muscular tissues than the animal.

But since the function creates the organ, and where function is not localized there is no variation of parts, life probably began in formless combinations having no visible distinction of parts. And as the cell is the first step in organization, it is the fundamental structure of living things, "it marks only where the vital tides have been or how they have acted," the lowest organisms consisting of one cell only, and the higher consisting of many cells, which, increasing in complexity or diversity of form adapted to their different functions at later stages, are modified into the special tissues, with resulting unlikeness in parts or organs, of which all plants and animals are composed. Every variation in structure is, therefore, due to cellular changes, and every living thing is propagated in one way or another by cells, by their self-division or multiplication; or by gemmation, *i. e.*, throwing off buds; or by the union

of like cells; or, in more complex mode, by the spontaneous or aided union of unlike cells, as the sperm-cell of the male with the germ-cell of the female, giving rise to a seed or egg from which grows offspring more or less like its parents.

In both plant and animal the cell-contents usually, although here again exceptions occur in some of the lowest organisms, exhibit a rounded body called the *nucleus*, which itself often incloses another body called the *nucleolus*, the functions performed by both of which in cell development are obscure. That even thus much is known of cell structure may awaken wonder when it is remembered that we are dealing with bodies for the most part beyond the range of our unaided vision. Bacon truly says that "the complexity of nature exceeds the subtlety of man"; the infinite divisibility and indivisibility of matter is apparent in the organic as in the inorganic; and size counts for little; the oak and pine, the acacia and the rose, are lower in scale of life than the thistle and the daisy; the elephant is 150,000 times heavier than the mouse, but the egg of the one is nearly as large as that of the other, and it has been calculated that if one molecule in the nucleus of the ovum of a mammal were to be lost in every second of time, the whole would not be exhausted in seventeen years.

These molecules are the sufficing material media of transmission of resemblances, both striking and subtle, between parent and offspring; and of the vast sum total of inherited tendencies, good or bad, which are the product of no one generation, but

which reach us charged with the gathered force of countless ancestral experiences.

“Born into life! man grows
Forth from his parents’ stem,
And blends their bloods, as those
Of theirs are blent in them;
So each new man strikes root into
a far fore-time.”

CLASSIFICATION OF PLANTS

—LOUIS FIGUIER

EVERY plant which grows on the surface of the earth or in the waters constitutes a distinct individuality. The careful examination and comparison of a certain number of these individuals of the vegetable world will lead to the admission that a great many are quite identical in some of their characteristics, while others possess no character in common. Examine the individual plants, for instance, which compose a field of oats; in each the root, the stem, the flowers, the fruit, present the same identical characters. The seed of any one whatever of these plants will yield other plants like those of the field. Every individual in the field belongs therefore to the same *species*—to the species *Avena sativa*.

The species, then, is a collection of all the individuals which resemble each other, and which will reproduce other individuals like themselves.

These species may present, as the result of diverse influences, such as change of climate or cultivation, differences more or less marked, more or less persistent, which withdraw them from the original type.

To these, according to their importance, botanists give the name of *varieties* and *sub-varieties*. The wheat-plant, the vine, the pear, the apple, and most of our cultivated legumes, all yield, under the influence of culture extending over a long series of years, plants altogether different from the original in their exterior; but they preserve, one and all, the essential characters of the species. They are *varieties* of the wheat-plant, of the vine, of the pear, of the apple.

The assemblage of a certain number of distinct species presenting the same general characteristics, the same disposition of organs, the same structure of flower and fruit, constitutes a group to which the name of *genus* is applied. *Rosa canina*, *R. villosa*, and *R. Sabini* are three different species of the same group—the genus *Rosa*. The words *oak*, *poplar*, *barley*, are collective common names, which served, long before botanical science existed, to designate certain groups of plants. These are true generic names of popular creation, which botanists have accepted because they were the result of exact observation. “A man of observant eye and quick intelligence,” says Auguste Pyramus de Candolle, “would observe certain groups in the vegetable kingdom which we call genera before discerning the species.”

The germs of botanical science are to be sought for in the rudimentary state in very remote antiquity. In the sacred writings we meet with constant allusions to the vegetable world. The cultivators of the science among the early Greeks and Romans were not botanists, but *Rhizotomæ*, or root-cutters, since they directed their attention to the roots in search of medic-

inal properties. Aristotle of Stagira, who lived in the fourth century before our era, may be regarded as the founder of botany; Mithridates, and the younger Juba, King of Mauritania, were among its cultivators. They established botanic gardens, some probably from love of the science, others of them in order to cultivate the deadly plants from which poisonous juices were obtained. Nicander of Colophon, Cato, Varro, Columella, Virgil, Pedanius Dioscorides of Cilicia, and lastly, the elder Pliny, all dwell upon the wonders of vegetation; and war, notwithstanding its desolating tendencies, was made to promote the interests of science.

To the Arabians of the Twelfth Century we are next indebted for our knowledge of botany. After them the darkness of the Middle Ages sets in, and it is only since the illustrious Venetian, Marco Polo, came to examine and describe the wonders of the East that the darkness has been dispelled. He examined the treasures of Asia and the east coast of Africa, described many plants of India and the Indian Ocean, and from his day to the present our knowledge of the names of plants, as well as of their structure and physiology, has been continually on the increase.

The science of botany, as now understood, can not be held, however, to date further back than two centuries. In the year 1682 Nehemiah Grew published his *Anatomy of Plants*. In 1684 the French botanist Tournefort, then professor of botany at the Jardin des Plantes, published his *Elements of Botany*, being the first attempt to define the exact limits of genera

in vegetables. Most of the genera established by Tournefort remain, proving the correctness of the formula from which he deduced their common characters. Tournefort succeeded to a large extent in unraveling the chaos into which the science of botany had been plunged from the days of Theophrastus and Dioscorides. Separating genera and species according to their characteristics, he described no less than 698 genera and 10,146 species. He published, at the same time, a system for the classification of plants, eminently attractive, especially if we connect it with the times in which it appeared. The French botanist directed the attention of observers, probably for the first time, to those parts of plants most likely to excite admiration, namely, the different forms of the corolla.

In selecting the form of the corolla as the basis of his classification, Tournefort has, perhaps, contributed more to the progress of botany than any other savant of any age. The task of instruction was rendered a pleasure by thus taking, as a subject of scientific inquiry, the most attractive part of the plant. He soon made adepts of those who had hitherto only contemplated flowers as the source of an agreeable sensation.

The system of Tournefort for the classification of plants met with great favor among his contemporaries, on account of its simplicity. Nevertheless, in its application, this system presented many difficulties. The form of the corolla is not always so exactly appreciable that the class to which that plant belongs can be settled from that character alone. But

the gravest defect of the system is, that by it the vegetable world is divided into two classes, namely, Herbaceous Plants and Trees—a division which has no existence in nature. The division destroys the natural analogies, for the size of a plant has no bearing upon its organization and structure. In conclusion, the continually increasing number of new species, which were unknown in Tournefort's time, tests, in the strongest manner, the defects of his system of distribution. The greater number of vegetable species discovered since Tournefort's time could not be placed in either of his classes. This defect soon became very apparent, and the system fell by degrees out of favor with botanists even among his own countrymen, with whom it had found most admirers.

In England the study of plants had taken a more philosophical direction. About the middle of the Seventeenth Century the microscope was first applied to the study of the organs of plants; and in 1661 spiral vessels were detected by Henshaw in the walnut tree, and shortly afterward the cellular tissues were examined by Hooke. These discoveries were followed by the publication of two works on the minute anatomy of plants by Malpighi and Grew. They examined the various forms of cellular tissues and intercellular passages in their minutest details, and with an exactness which causes their works still to be recognized as the groundwork of all physiological botany. The real nature of the sexual organs in plants was demonstrated by Grew; the important difference between the seeds with one and those with

two cotyledons was first pointed out by him. Clear and distinct ideas of the causes of vegetable phenomena were gradually developed, and a solid foundation laid on which the best theories of vegetation have been formed by subsequent botanists.

About the time when Tournefort was engaged in arranging his system of plants, and when Grew had completed his microscopical observations, John Ray was driven from his collegiate employments at Cambridge by differences of opinion with the ruling powers of his university. He sought and found consolation in the study of natural history, to which he was ardently attached, and for which his powers of observation, capacious mind, and extensive learning so highly qualified him. Profiting by the discoveries of Grew and other vegetable anatomists, in 1686 he published the first volume of his *Historia Plantarum*, in which are embodied all the facts connected with the structure and organs of plants, with an exposition of the philosophy of classification, the merits of which are better appreciated now than they were in his own days.

Ray was careful to guard his readers against the supposition that classification was other than a means of identification. He argued that there was no line of demarcation in nature between one group or order, or even genus, and another, or that any system could be perfect.

While he enumerated the true uses of classification, Ray also laid the foundations of the natural system, which has since been universally adopted by botanists. He separated flowerless from flowering

plants, and he divided these again into Monocotyledonous and Dicotyledonous plants.

Forty years after the publication of Tournefort's system, and while Ray was yet pursuing his philosophical investigations, the Linnæan system appeared. This new mode of distributing vegetable species was hailed with admiration. Its author, Charles von Linnæus, reigned supreme and without a rival till the end of the Eighteenth Century, and even in our days his partisans are neither few nor powerless. In Germany, for instance, more than one botanical work of character has for foundation the system of Linnæus, and many school-gardens are arranged after his classification.

The system of Linnæus rests upon the consideration of the organs of fecundation—organs almost overlooked until then, but whose physiological functions have since been ably demonstrated. He introduced in 1736 a salutary and much-wanted reform into botanical language and nomenclature, defining most rigorously the terms used to express the various modifications and characters of the organs, and reducing the name of each plant to two words, the first designating the genus, the second designating a species of the genus. Before his time, in fact, it was necessary to follow the name of the genus through a whole sentence in order to characterize the species, and in proportion as the number of species increased, the sentences were lengthened until it seemed as if they would never come to an end. It was like the confusion which would arise in society if, in place of using the baptismal name and surname, we were to suppress

the baptismal name, and substitute for it an enumeration of many qualities distinctive of the individual; as if, for example, in place of saying Pierre Durand or Louis Durand, we said Durand the great sportsman, or any other phraseology applicable to the qualities of the individual. Nevertheless the Linnæan or binary nomenclature is one of the great titles to that glory which has been awarded to its immortal author. In the scheme of the Linnæan system it has been found possible to describe all plants discovered since his time—an irrefragable proof of the great merits of this artificial classification of species.

This classification of plants has received the name of the artificial system, because it groups the species according to a small number and not from the whole of their characteristics; in short, it rather permits one class to be distinguished from another than makes each known in an intimate manner. It insists much upon their differences, little upon their resemblances. Between species thus compared, only one essential analogy may exist. The rush takes place beside the barberry, because each of these plants has six stamens and only one style. The vine is ranged beside the periwinkle, because they each have five stamens and one style. The carrot is allied to the gooseberry, etc. There may not be between the plants thus compared any natural bond, but only some trace of resemblance in a particular part of the organization, which may be found also in a number of very different plants.

Linnæus was endowed with too sound a judgment, with a tact too exquisite, not to feel the defects of this

artificial mode of classification. He detected by the force of his genius the existence of vegetable groups superior to genera, and connected them by a large number of characteristics. He called this group a *natural order*, and it has since his time been called a "natural family." He also tried to distribute plants after a natural classification—that is to say, into families. After the death, and during the life, of Linnæus, botanists endeavored to discover upon what principle he had founded his *natural orders*—that is to say, they sought to find the key to the hidden principle of his orders; but no one has succeeded. Linnæus himself does not appear to have had very fixed views on the subject. He created his orders by a sort of instinct which belongs only to the man of genius; by that kind of semi-divination which the man of learning acquires who possesses vast and profound knowledge of the objects which he passes his life in observing.

In a letter we find the following passage: "You ask me for the characters of my orders. My dear Giseke, I assure you that I know not how to give them."

Magnol, professor of botany to the School of Medicine, in his work entitled *Prodromus Historiæ Generalis Plantarum* (1689), is the first author who uses the happy term "family" to designate natural groups of vegetable genera. M. Flourens speaks of the preface to this little book of a hundred pages as calculated to immortalize the author, as in it was first solved a very difficult problem. The following lines are taken from this much-admired preface: "Hav-

ing examined the methods most in use," says Magnol, "and found that of Morison insufficient and very defective, and that of Ray much too difficult, I think I can perceive in plants a certain affinity between them, so that they might be ranged in divers *families*, as we class animals. This apparent analogy between animals and plants has induced me to arrange them in certain families, and, as it appeared to me impossible to draw the characters of these families from the single organ of fructification, I have selected principally the most noted characteristics I have met with, such as the root, the stem, the flower, the seeds. There is also found among plants *a certain similitude*, a certain affinity, as it were, which does not exist in any of the parts considered separately, but only as a whole. I have no doubt, for instance, but that the characters of families might be taken from the first leaf of the germ as it issued from the seed. I have followed the order that the parts of plants follow in which are found the principal and distinctive characters of families, but without limiting myself to any one single part, for I have often considered many of them together."

Magnol established seventy-six families, but without giving their characters. His principles of classification are vague and uncertain; they only serve to announce the dawn of a new day which was soon to rise on the science. The few lines which we have quoted from the preface of the *Prodromus* reveal, as through a fog, the mere idea of a natural system. It is Bernard de Jussieu, demonstrator of botany in the Jardin des Plantes at Paris, to whom belongs the

glory of working out the true natural system which was first established in principle by Ray, although it does not appear that Jussieu was acquainted with the works of the English philosopher.

"Others may perhaps have extended the limits, but he was the first to show the way, to trace the method, to establish the principles. Jussieu consigned his discoveries to no book, but in the Gardens of Trianon the mind of the author is recognized. In examining the characters, he remarked that some were more general than others, and these furnished the first division. He recognized that the germination of the seed and the respective disposition of the sexual organs were the two principal and most persistent characteristics. He adopted them, and made them the basis of the arrangement which he established at the Trianon in 1759."

Four years later, another French botanist, Michel Adanson, a naturalist remarkable for the originality of his views and the extent of his conceptions, published a book upon the families of plants. He proposed a particular course for arriving at the true natural method. But what was that course? He proposed classing all the plants known according to a great number of artificial systems; and after considering them from all possible points of view, he proposed to arrange in the same group those plants which were classed as allies in the greatest number of systems. In this manner Adanson created sixty-five artificial systems, and by their comparison he formed fifty-eight families. He was the first to trace the precise characters and details of all these families;

his work in this respect is far superior to those of his predecessors.

The year 1789 was the date of the real establishment of natural families among vegetables. It was in this year that Laurent de Jussieu published his celebrated *Genera Plantarum*, which marked a new era in the science of botany, and hastened the advent of a natural system of zoological classification as well.

The catalogues of the Gardens of the Trianon, prepared by Bernard de Jussieu, and his conversations with his nephew, were the source whence the latter drew his inspirations.

That the French botanist had acquainted himself with the principles of Ray's classification is unquestionable; in fact, Jussieu possessed the happy art of adapting the labors of others to perfecting his own conceptions. He made use of the simple language and accurate descriptions of Linnæus, divested of his pedantry. Ray had demonstrated that rigorous definitions in natural history are impossible, and, accepting the decision, Jussieu does not attempt to found his family orders or genera on any single character belonging to objects so various in their habits and organization as plants.

During the last forty or fifty years other botanists have attempted various systems of classification. In those of De Candolle, Endlicher, Lindley, and of Brongniart, the distribution of plants into groups is founded, as in those of Ray and Jussieu, on the consideration of the cotyledons; of the polypetalous, monopetalous, and apetalous flowers; finally, upon the mode of insertion of the stamens. Names have

changed; things remain the same; and if in their details the series of families or orders present certain differences, it only arises from the fact that a linear series is incompatible with the natural system, and that the connection of the intermediate groups may be expressed in various ways without affecting the general principles of the system. "The formation of natural orders by Jussieu," says Ad. Brongniart, "is even now a model which directs botanists in their studies to the affinity which connects the various forms of vegetation. Many of these orders have doubtless been subjected to important modifications, both in extending and limiting them; the numbers have been more than doubled; but the number of species now known is increased more than sixfold. Since the publication of the *Genera Plantarum*, many points in the organization of plants which were either scarcely touched upon or were altogether unsuspected, have now been considered, and it is found that they do not destroy, but confirm and perfect the work of Jussieu. One is even astonished to find that the numerous discoveries in the anatomy and organography of plants since the beginning of the century have not introduced greater modifications into the constitution of the natural groups admitted by the author of the *Genera Plantarum*. It is here that we recognize the sagacity of the savant who established them, and the soundness of the principle which guided him."

The natural classification of plants, their distribution into families, well defined, and founded upon affinities, have been perfected and placed upon a basis



Flowers, Curious and Beautiful

1, Edelweiss; 2, *Nigella Arvensis*; 3, *Parnassia*; 4, *Rhododendron*; 5, *Ophrys Arachnites*;
6, *Cypripedium Calceolus*; 7, *Nepenthes*; 8, *Gnaphalium Dioicum*; 9, *Ophrys Muscifera*

more and more certain in our own days. Botanists have set themselves the task of unraveling and establishing the characters which dominate, and those which are subordinate, in each family; numbers have spread themselves over the globe, exploring the most distant regions, interrogating the solitudes of forests and plains which no European had hitherto visited, and have studied in their native wilds many exotic plants, comparing them with already known species, thus giving us a means of pointing out more precisely the tribes, genera, and species of each natural family. Monographs of a great number of such families have thus been written with great research. The study of the formation and evolution of organs; the discovery of the true mode of reproduction in cryptogams, still unknown in Jussieu's time; the investigation of the inflorescence, of the fruits, of the ovules, of the embryos, have furnished elements for perfecting the limits of families and advancing natural classification.

Auguste Pyramus de Candolle is one of the botanists of the last century who has most contributed to the general adoption of natural families. His *Essai sur les Propriétés des Plantes* is celebrated for the knowledge which it displays of the comparative physiological and medicinal action of vegetables, and the physical organization which naturally connects certain plants as a group. His *Prodromus Systematis Naturalis Regni Vegetabilis*, continued by his pupils and his son, is a wonderful work for the extent and precision of its details.

In Great Britain, from the days of Ray, we have

always had zealous followers of the science of botany, more especially in the class which may be called field botanists. Withering, Sir James Edward Smith, and hundreds of followers more or less eminent, employed their leisure in the fascinating and healthy pursuit of plants, and perhaps the most valuable contributions to science are the detailed descriptions of species, with their habits and habitats, with which they have enriched our botanical literature. Nor was the study of the physiology of plants—a science which may be said to owe its existence to the researches of Grew and Malpighi—neglected. To the former belongs the merit of having pointed out the difference between seeds with one and seeds with two cotyledons, on which Ray founded the first division of his system of classification.

The German botanists have always been distinguished for their patient and laborious investigations; and it was reserved for the first of Germans, the poet Goethe, to effect the last great revolution that the ideas of botanists have undergone. In 1790, shortly after the appearance of De Jussieu's *Genera*, he published a pamphlet on the *Metamorphoses of Plants*. At this time the functions of the organs of plants were supposed to be pretty well understood. The notion had, however, existed in a form more or less vague, from the times of Theophrastus, that the various parts of the flower were mere modifications of leaves, although their appearance was very different—a doctrine which Linnæus seems to have entertained at one time, as he speaks, in his *Prolepsis Plantarum*, of the parts of a flower being mere mod-

ifications of leaves whose period of development was anticipated. Goethe's mind was, as he himself tells us, one more adapted to see agreements in things than to mark their distinctions. We are not surprised to find, therefore, that he takes up this theory, and demonstrates that the organs to which so many different names are applied—namely, the bracts, calyx, corolla, stamens, and pistil—are all modifications of the leaf: the bract being a contracted leaf; the calyx and corolla a collection or whorl of several; the stamens contracted and colored leaves; and the pistils leaves rolled up upon themselves and variously coherent.

These views of the poet met at first with little attention from botanists, and we are chiefly indebted to Robert Brown for the elucidation of Goethe's theory. In his *Prodromus of the Plants of New Holland*, and in many papers in the *Linnæan Transactions*, he demonstrates its truth as well as its practical value; showing, by the use of the microscope, that the law was applicable not only to the external parts of plants, but that it was followed in their development also. Robert Brown contributed largely to perfecting the natural method of classification. His great work upon the flora of Australia has greatly extended the circle of our studies for that comparison of characters which is the basis of botanical genera and tribes.

The number of families of flowering plants admitted in the present day, as the result of the investigations of the eminent men whose names have been mentioned, and many others which could not be quoted here without swelling our pages to undue pro-

portions, number three hundred and three; and many of these are again subdivided by botanists who have made certain families their special study.

The primary groups into which flowering plants are divided, and in which therefore the families or orders are themselves comprised in the classification at present accepted, being founded upon the degree of cohesion and adhesion in the petals and stamens, are undoubtedly somewhat artificial. The problem of how the orders are themselves to be combined into natural groups is one which still engages the attention of systematic botanists.

The vegetable kingdom is divided by Dr. Lindley into seven classes:

FLOWERLESS PLANTS (CRYPTOGAMS)

I. THALLOGENS { Stems and leaves
imperceptible.

A Thallus is a fusion of root, stem, and leaves into one general mass, and Thallogens are destitute of breathing pores, and multiply by the formation of spores, in their interior or upon their surface.

II. ACROGENS { Stems and leaves
quite perceptible.

Beyond Thallogens are multitudes of species, flowerless like them, but approximating to more complex structures, sometimes acquiring the stature of lofty trees with breathing pores; their leaves and stems distinctly separated; they multiply by reproductive spores like the Thallogens. Their stem, however, does not increase in diameter, but at their summit, as the name of the class indicates.

FLOWERING PLANTS (PHANEROGAMS)

III. RHIZOGENS { Fructification
springing from a
Thallus.

The Rhizogens are a collection of anomalous plants, mostly leafless and parasitical, having the loose cellular organization of Fungi, although traces of a spiral structure are usually found among their tissues. Some of them spring directly from the shapeless cellular mass which serves at once for stem and root, and seems to be analogous to the Thallus of the Fungi. Their flowers resemble those of more perfect plants; their sexual organs are complete, but their embryo, which is without any visible radicle or cotyledon, simply appears to be a spherical or oblong homogeneous mass.

IV. ENDOGENS { Cotyledon single.
Permanent woody
stem confused. Leaves
parallel-veined.

In Endogens the embryo has but one cotyledon; the leaves have parallel veins; the trunk contains bundles of spiral and dotted vessels, surrounded by wood cells, arranged in a confused manner.

V. DICTYOGENS { Cotyledon single.
Wood of the stem,
when perennial, ar-
ranged in rings con-
centric with the veined
pith. Leaves netted.

Dictyogens are distinguished from Endogens by the stems, which have concentric circles, and the leaves which fall off the stem by a clean fracture.

VI. GYMNOGENS { Cotyledons, two
or more. Wood of
the stem in concen-
tric rings, and young-
est at the circumfer-
ence. Seeds quite
naked.

Gymnogens are Exogens which have no style or stigma, the reproductive organs being so constructed that the pollen falls immediately upon the ovules.

VII EXOGENS

Cotyledons, two.
 Wood with concentric rings. Leaves netted-veined. Seeds inclosed in seed-vessels.

Exogens have an embryo with two or three more cotyledons; leaves with netted veins; the trunk consisting of woody bundles, composed of dotted vessels and woody fibres; arranged round a central pith, either in concentric rings or in a homogeneous mass, but always having medullary plates forming rays from the centre to the circumference.

FRUITS AND SEEDS

—LORD AVEBURY

FRUITS and seeds, though not generally so conspicuous as flowers, are not less interesting.

In considering them, it is fortunately not necessary to use many technical terms, though it is impossible to avoid them altogether. In order to understand the structure of the seed, we must commence with the flower, to which the seed owes its origin. Now, if you take such a flower as, say, a geranium, you will find that it consists of the following parts: Firstly, there is a whorl of green leaves, known as the sepals, and together forming the calyx; secondly, a whorl of colored leaves, or petals, generally forming the most conspicuous part of the flower, and called the corolla; thirdly, a whorl of organs more or less like pins, which are called stamens, in the heads or anthers of which the pollen is produced. These anthers are in reality, as Goethe showed, modified leaves; in the so-called double flowers, as, for instance, in our garden roses, they are developed into

colored leaves like those of the corolla, and monstrous flowers are not infrequently met with, in which the stamens are green leaves, more or less resembling the ordinary leaves of the plant. Lastly, in the centre of the flower is the pistil, which also is theoretically to be considered as constituted of one or more leaves, each of which is folded on itself, and called a carpel. Sometimes there is only one carpel. Generally the carpels have so completely lost the appearance of leaves, that this explanation of their true nature requires a considerable amount of faith, though in others, as for instance in the Columbine (*Aquilegia*), the original leaf-form can still be traced. The base of the pistil is the ovary, composed of one or more carpels, in which the seeds are developed. I need hardly say that many so-called seeds are really fruits; that is to say, they are seeds with more or less complex envelopes.

We all know that seeds and fruits differ greatly in different species. Some are large, some small; some are sweet, some bitter; some are brightly colored; some are good to eat, some poisonous; some spherical, some winged, some covered with bristles, some with hairs; some are smooth, some very sticky.

We may be sure that there are good reasons for these differences. In the case of flowers much light has been thrown on their various interesting peculiarities by the researches of Sprengel, Darwin, Müller, and other naturalists. As regards seeds also, besides Gärtner's great work, Hildebrand, Krause, Steinbrinck, Kerner, Grant Allen, Wallace, Darwin, and others, have published valuable researches, espe-

cially with reference to the hairs and hooks with which so many seeds are provided, and the other means of dispersion they possess. Nobbe also has contributed an important work on seeds, principally from an agricultural point of view, but the subject as a whole offers a most promising field for investigation.

It is said that one of our best botanists once observed to another that he never could understand what was the use of the teeth on the capsules of mosses. "Oh," replied his friend, "I see no difficulty in that, because if it were not for the teeth, how could we distinguish the species?"

We may, however, no doubt, safely consider that the peculiarities of seeds have reference to the plant itself, and not to the convenience of botanists.

In the first place, then, during growth, seeds in many cases require protection. This is especially the case with those of an albuminous character. It is curious that so many of those which are luscious when ripe, as the peach, strawberry, cherry, apple, etc., are stringy, and almost inedible, till ripe. Moreover, in these cases, the fleshy portion is not the seed itself, but only the envelope, so that even if the sweet part is eaten the seed itself remains uninjured.

On the other hand, such seeds as the hazel, beech, Spanish chestnut, and innumerable others, are protected by a thick, impervious shell, which is especially developed in many Proteaceæ, the Brazil-nut, the so-called monkey-pot, the cocoanut, and other palms.

In other cases the envelopes protect the seeds, not

only by their thickness and toughness, but also by their bitter taste, as, for instance, in the walnut. The genus *Mucuna*, one of the Leguminosæ, is remarkable in having the pods covered with stinging hairs.

In many cases the calyx, which is closed when the flower is in bud, opens when the flower expands, and then after the petals have fallen closes again until the seeds are ripe, when it opens for the second time. This is, for instance, the case with the common herb Robert (*Geranium robertianum*). In *Atractylis cancellata*, a south European plant, allied to the thistles, the outer envelopes form an exquisite little cage. Another case, perhaps, is that of *Nigella*, the "devil-in-a-bush," or, as it is sometimes more prettily called, "Love-in-a-mist," of old English gardens.

Again, the protection of the seed is in many cases attained by curious movements of the plant itself.

The sleep of flowers is also probably a case of the same kind, though it has, I believe, special reference to the visits of insects; those flowers which are fertilized by bees, butterflies, and other day insects, sleep by night, if at all; while those which are dependent on moths rouse themselves toward evening, and sleep by day. On the other hand, in the dandelion (*Leontodon*), the flower-stalk is upright while the flower is expanded, a period which lasts for three or four days; it then lowers itself and lies close to the ground for about twelve days, while the fruits are ripening, and then rises again when they are mature. In the *Cyclamen* the stalk curls itself up into a beautiful spiral after the flower has faded.

The flower of the little *Linaria* of our walls (*L. cymbalaria*) pushes out into the light and sunshine, but as soon as it is fertilized it turns round and endeavors to find some hole or cranny in which it may remain safely ensconced until the seed is ripe.

In some water-plants the flower expands at the surface, but after it is faded retreats again to the bottom. This is the case, for instance, with the water lilies, some species of *Potamogeton*, *Trapa natans*, etc. In *Valisneria*, again, the female flowers are borne on long stalks, which reach to the surface of the water, on which the flowers float. The male flowers, on the contrary, have short, straight stalks, from which, when mature, the pollen detaches itself, rises to the surface, and, floating freely on it, is wafted about, so that it comes in contact with the female flowers. After fertilization, however, the long stalk coils up spirally, and thus carries the ovary down to the bottom, where the seeds can ripen in greater safety.

Farmers have found by experience that it is not desirable to grow the same crop in the same field year after year, because the soil becomes more or less exhausted. In this respect, therefore, the powers of dispersion possessed by many seeds are a great advantage to the species. Moreover, they are also advantageous in giving the seed a chance of germinating in new localities suitable to the requirements of the species. Thus a common European species, *Xanthium spinosum*, has rapidly spread over the whole of South Africa, the seeds being carried in the wool of sheep.

There are a great many cases in which plants possess powers of movement directed to the dissemination of the seed.

Some plants even sow their seeds in the ground. In other cases the plant throws its own seeds to some little distance. This is the case with the common *Cardamine hirsuta*, a little plant six or eight inches high, which comes up of itself abundantly on any vacant spot in kitchen-gardens or shrubberies. The seeds are contained in a pod which consists of three parts, a central membrane, and two lateral walls. When the pod is ripe the walls are in a state of tension. The seeds are loosely attached to the central piece by short stalks. Now, when the proper moment has arrived, the outer walls are kept in place by a delicate membrane, only just strong enough to resist the tension. The least touch, for instance, a puff of wind blowing the plant against a neighbor, detaches the outer wall, which suddenly rolls itself up, generally with such force as to fly from the plant, thus jerking the seeds to a distance of several feet.

In the common violet, besides the colored flowers, there are others in which the corolla is either absent or imperfectly developed. The stamens also are small, but contain pollen, though less than in the colored flowers. In the autumn large numbers of these curious flowers are produced. When very young they look like an ordinary flower-bud, the central part of the flower being entirely covered by the sepals, and the whole having a triangular form. When older, they look at first sight like an ordinary

seed capsule, so that the bud seems to pass into the capsule without the flower-stage.

Some species of Vetch, and the common Broom, throw their seeds, owing to the elasticity of the pods, which, when ripe, open suddenly with a jerk. Each valve of the pod contains a layer of woody cells, which, however, do not pass straight up the pod, but are more or less inclined to its axis. Consequently, when the pod bursts, it does not, as in the case of Cardamine, roll up like a watch-spring, but twists itself more or less like a corkscrew.

I have mentioned these species because they are some of the commonest British wild flowers, so that during the summer and autumn we may in almost any walk observe for ourselves this innocent artillery. There are, however, many other more or less similar cases.

Thus the Squirting Cucumber (*Momordica elaterium*), a common plant in the south of Europe, and one grown in some places, for medicinal purposes, effects the same object by a totally different mechanism. The fruit is a small cucumber, and when ripe becomes so gorged with fluid that it is in a state of great tension. In this condition a very slight touch is sufficient to detach it from the stalk, when the pressure of the walls ejects the contents, throwing the seed some distance. I have seen them even in England sent nearly twenty feet; but in a hotter climate the plant grows more vigorously, and they would doubtless be thrown further. In this case, of course, the contents are ejected at the end by which the cucumber is attached to the stalk. If any one

touches one of these ripe fruits, they are often thrown with such force as to strike him in the face.

In *Cyclanthera*, a plant allied to the cucumber, the fruit is unsymmetrical, one side being round and hairy, the other nearly flat and smooth. The true apex of the fruit which bears the remains of the flower, is also somewhat eccentric, and, when the seeds are ripe, if it is touched even lightly, the fruit explodes and the seeds are thrown to some distance.

Other cases of projected seeds are afforded by *Impatiens*, *Hura*, one of the *Euphorbiæ*, *Collomia*, *Oxalis*, some species allied to *acanthus*, and by *Arceuthobium*, a plant allied to the mistletoe, and parasitic on juniper, which ejects its seeds to a distance of several feet, throwing them thus from one tree to another.

Even those species which do not eject their seeds often have them so placed with reference to the capsule that they only leave it if swung or jerked by a high wind. In the case of trees, even seeds with no special adaptation for dispersion must in this manner be often carried to no little distance; and to a certain, though less, extent, this must hold good even with herbaceous plants. It throws light on the, at first sight, curious fact that in so many plants with small, heavy seeds, the capsules open not at the bottom, as one might perhaps have been disposed to expect, but at the top. A good illustration is afforded by the well-known case of the common poppy, in which the upper part of the capsule presents a series of little doors, through which, when the plant is swung by the wind, the seeds come out one by one.

The little doors are protected from rain by overhanging eaves, and are even said to shut of themselves in wet weather. The genus *Campanula* is also interesting from this point of view, because some species have the capsules pendent, some upright, and those which are upright open at the top, while those which are pendent do so at the base.

In other cases the dispersion is mainly the work of the seed itself. In some of the lower plants, as, for instance, in many seaweeds, and in some allied fresh-water plants, such as *Vaucheria*, the spores* are covered by vibratile cilia, and actually swim about in the water, like infusoria, till they have found a suitable spot on which to grow. Nay, so much do the spores of some seaweeds resemble animals that they are provided with a red "eye-spot," as it has been called, which, at any rate, seems so far to deserve the name that it appears to be sensitive to light. This mode of progression is, however, only suitable to water plants. In much more numerous cases, seeds are carried by the wind.

In other instances, the plants themselves, or parts of them, are rolled along the ground by the wind. An example of this is afforded, for instance, by a kind of grass (*Spinifex squarrosus*), in which the mass of inflorescence, forming a large, round head, is thus driven for miles over the dry sands of Australia until it comes to a damp place, when it expands and soon strikes root.

So, again, the *Anastatica hierochuntica*, or "Rose

* I need hardly observe that, botanically, these are not true seeds, but rather motile buds.

of Jericho," a small annual with rounded pods, which frequents sandy places in Egypt, Syria, and Arabia, when dry, curls itself up into a ball or round cushion, and is thus driven about by the wind until it finds a damp place, when it uncurls, the pods open and sow the seeds.

These cases, however, in which seeds are rolled by the wind along the ground, are comparatively rare. There are many more in which seeds are wafted through the air.

Another mode, which is frequently adopted, is the development of long hairs. Sometimes, as in *Clematis*, *Anemone*, and *Dryas*, these hairs take the form of a long, feathery awn. In others the hairs form a tuft or crown, which botanists term a pappus. Of this the dandelion and John Go-to-bed-at-noon, so called from its habit of shutting its flowers about midday, are well-known examples. Tufts of hairs, which are themselves sometimes feathered, are developed in a great many composites, though some, as, for instance, the daisy and *lapsana*, are without them; in some very interesting species, of which the common *Thrincia hirta* of our lawns and meadows is one, there are two kinds of fruits, one with a pappus and one without. The former are adapted to seek "fresh woods and pastures new," while the latter stay near the parent plant and perpetuate the race at home.

In other cases seeds are wafted by water. Of this the cocoanut is one of the most striking examples. The seeds retain their vitality for a considerable time, and the loose texture of the husk protects them

and makes them float. Every one knows that the cocoanut is one of the first plants to make its appearance on coral islands, and it is, I believe, the only palm which is common to both hemispheres.

In a very large number of cases the diffusion of seeds is effected by animals. To this class belong the fruits and berries. In them an outer fleshy portion becomes pulpy, and generally sweet, inclosing the seeds. It is remarkable that such fruits, in order, doubtless, to attract animals, are, like flowers, brightly colored—as, for instance, the cherry, currant, apple, peach, plum, strawberry, raspberry, and many others. This color, moreover, is not present in the unripe fruit, but is rapidly developed at maturity. In such cases the actual seed is generally protected by a dense, sometimes almost stony, covering, so that it escapes digestion, while its germination is, perhaps, hastened by the heat of the animal's body. It may be said that the skin of apple and pear pips is comparatively soft; but then they are imbedded in a stringy core, which is seldom eaten.

These colored fruits form a considerable part of the food of monkeys in the tropical regions of the earth, and we can, I think, hardly doubt that these animals are guided by the colors, just as we are, in selecting the ripe fruit.

In these instances of colored fruits, the fleshy edible part more or less surrounds the true seeds; in others the actual seeds themselves become edible. In the former the edible part serves as a temptation to animals; in the latter it is stored up for the use of the plant itself. When, therefore, the seeds them-

selves are edible they are generally protected by more or less hard or bitter envelopes, for instance, the horse chestnut, beech, Spanish chestnut, walnut, etc. That these seeds are used as food by squirrels and other animals is, however, by no means necessarily an evil to the plant, for the result is that they are often carried some distance and then dropped, or stored up and forgotten, so that in this way they get carried away from the parent tree.

In another class of instances, animals, unconsciously or unwillingly, serve in the dispersion of seeds. These cases may be divided into two classes, those in which the fruits are provided with hooks and those in which they are sticky. The hooks, moreover, are so arranged as to promote the removal of the fruits. In all these species the hooks, though beautifully formed, are small; but in some species they become truly formidable. Two of the most remarkable are *Martynia proboscidea* and *Harpagophyton procumbens*. *Martynia* is a plant of Louisiana, and if its fruits once get hold of an animal it is most difficult to remove them. *Harpagophyton* is a South African genus. The fruits are most formidable, and are said sometimes to kill lions. They roll about over the dry plains, and if they attach themselves to the skin, the wretched animal tries to tear them out, and sometimes getting them into his mouth perishes miserably.

The cases in which the diffusion of fruits and seeds is effected by their being sticky are less numerous, and we have no well-marked instance among our native plants. The common plumbago of South

Europe is a case which many of you no doubt have observed. Other genera with the same mode of dispersion are *Pittosporum*, *Pisonia*, *Boerhavia*, *Siegesbeckia*, *Grindelia*, *Drymaria*, etc. There are comparatively few cases in which the same plant uses more than one of these modes of promoting the dispersion of its seeds, still there are some such instances. Thus in the common burdock the seeds have a pappus, while the whole flower-head is provided with hooks which readily attach themselves to any passing animal. *Asterothrix*, as Hildebrand has pointed out, has three provisions for dispersion: it has a hollow appendage, a pappus, and a rough surface.

The next point is that seeds should find a spot suitable for their growth. In most cases, the seed lies on the ground, into which it then pushes its little rootlet. In plants, however, which live on trees, the case is not so simple, and we meet some curious contrivances. Thus, the mistletoe, as we all know, is parasitic on trees. The fruits are eaten by birds, and the droppings often, therefore, fall on the boughs; but if the seed was like that of most other plants it would soon fall to the ground, and consequently perish. Almost alone among those of English plants it is extremely sticky, and thus adheres to the bark.

I have already alluded to an allied genus, *Arceuthobium*, parasitic on junipers, which throws its seeds to a distance of several feet. These also are very viscid, or, to speak more correctly, are imbedded in a very viscid mucilage, so that if they

come in contact with the bark of a neighboring tree they stick to it.

Among terrestrial species there are not a few cases in which plants are not contented simply to leave their seeds on the surface of the soil, but actually sow them in the ground.

I have already alluded to the *Cardamines*, the pods of which open elastically and throw their seeds some distance. A Brazilian species, *C. chenopodiifolia*, besides the usual long pods, produces also short, pointed ones, which it buries in the ground.

Arachis hypogæa is the ground-nut of the West Indies. The flower is yellow and resembles that of a pea, but has an elongated calyx, at the base of which, close to the stem, is the ovary. After the flower has faded, the young pod, which is oval, pointed, and very minute, is carried forward by the growth of the stalk, which becomes several inches long and curves downward so as generally to force the pod into the ground. If it fails in this, the pod does not develop, but soon perishes; on the other hand, as soon as it is underground the pod begins to grow and develops two large seeds.

A remarkable instance is afforded by a beautiful south European grass, *Stipa pennata*, the structure of which has been described by Vaucher, and more recently, as well as more completely, by Frank Darwin. The actual seed is small, with a sharp point, and stiff, short hairs pointing backward. The upper end of the seed is produced into a fine twisted corkscrew-like rod, which is followed by a plain cylindrical portion, attached at an angle to the corkscrew,

and ending in a long and beautiful feather, the whole being more than a foot in length. The long feather, no doubt, facilitates the dispersion of the seeds by wind; eventually, however, they sink to the ground, which they tend to reach, the seed being the heaviest portion, point downward. So the seed remains as long as it is dry, but if a shower comes on, or when the dew falls, the spiral unwinds, and if, as is most probable, the surrounding herbage or any other obstacle prevents the feathers from rising, the seed itself is forced down and so driven by degrees into the ground.

LEAVES.—R. LLOYD PRAEGER

THE stems of plants are the framework on which the leaves and flowers are spread out to catch the light and air, and we find definite relations existing between the form, position, and strength of stems, and the shape, weight, and function of the organs which the stems support. The branches of an apple or pear tree have to be sufficiently strong not only to withstand the stress of winter gales, and the burden, of the wealth of blossom and foliage of early summer, but also the weight of the abundant fruit of autumn. It is interesting to note that among our cultivated fruits strength of stem has not kept pace with the increase in weight of fruit due to artificial selection, so that in gardens our artificial fruits must needs, in a season of abundance, be supported by artificial stems—by props and crutches—lest, like the legs of the prize turkey in the *Christmas Carol*, the

branches might snap like sticks of sealing-wax. In evergreen trees, the weight of snow is a serious contingency that must not be neglected. Nor must the chance of accident owing to wandering animals be left out of account. The young ash saplings, a few feet in height, are as pliable as willow-wands, and spring back into their places as we force our way through them; but the knobby twigs of an old ash tree, which swing clear in the air high overhead, are brittle, and snap across if we attempt to bend them; the elasticity of the whole bough is sufficient to bring them safely through the heaviest storm.

Between the form of a twig and that of the leaves which it bears we can generally at once perceive a relation. The little leaves of the birch are borne on twigs slender as a piece of twine. The oak and elm, with larger leaves, require a stouter twig for their support. The sycamore and ash have twigs which are stouter still. The large leaves of the horse chestnut are borne on very thick twigs, in which the principle of the hollow column is introduced.

The arrangement of the leaves on the stem, or *phyllotaxis*, is a question of the first importance. The leaves must be so grouped that all may receive as much light as possible. So far as can be arranged, there should be no overlapping, nor should any of the available space be wasted. On the stem of the ash, or sycamore, or teazel, the large leaves are arranged in alternate pairs, the direction of the axis of each pair being at right angles to that of the next. Thus two spaces or *internodes* separate any pair of leaves from the nearest pair which, being placed in

the same position, might overshadow it. This is a very simple case, which we shall find to be the rule when we examine plants in which the leaves are borne in opposite pairs. When leaves are borne in whorls of three a similar rule will be found to hold good. The position of the leaves of any whorl is such that they are vertically below or above the *spaces* between the leaves of the next whorl. It will be seen at once that the amount of light received by each leaf is materially increased by this arrangement. If in a theatre we can look between the heads of two people in the row immediately in front of us, the head of a person in the next row beyond, even though directly before us, does not much interfere with our view of the stage. In most cases, however, the arrangement of the leaves on the stem is much more complicated than this. The leaves usually emerge singly. If we join by a line the point of emergence of a leaf with that of the next leaf above it on a stem, and that again with the next, a spiral will be the result, along which at equal intervals we reach the *nodes*, or points where leaves are borne. And the distance between these nodes will be always found to bear some definite relation to the total length of the spiral line in making one complete revolution round the stem. If the distance from node to node is one-half of this whole distance, it signifies that the leaves are borne alternately on opposite sides of the stem, each leaf being vertically below the second one higher up the stem—a very common arrangement. Or the leaves may be borne three to each spiral revolution, so that the position of each leaf shifts one-third way round the

stem as compared with the preceding leaf. If we look along such a stem, the leaves will appear to be borne in three vertical rows, with an equal angle between each. Examining some other plant, we may find that we have to go as far as the fifth leaf before we find one vertically above the one from which we started, and if we measure the horizontal distance from any leaf to the next above or below it, it will be found to equal two-fifths of the total circumference, so that we have to go five times two-fifths way round the stem, or two complete revolutions, before completing the cycle. This is called a two-fifths phyllotaxis. In many other cases, the arrangement is immensely more complicated, and need not be entered on here. What is important for us to note at present is that by means of this orderly mathematical arrangement, the leaves are so distributed that each fulfils its functions to the best advantage.

The shape of leaves offers an almost inexhaustible field for observation and scientific speculation. Mr. Ruskin has said: "The leaves of the herbage at our feet take all kinds of strange shapes, as if to invite us to examine them. Star-shaped, heart-shaped, spear-shaped, arrow-shaped, fretted, fringed, cleft, furrowed, serrated, sinuated, in whorls, in tufts, in spires, in wreaths, endlessly expressive, deceptive, fantastic, never the same from footstalk to blossom, they seem perpetually to tempt our watchfulness and take delight in outstripping our wonder." The size of leaves will naturally vary inversely as their number. A plant of a certain size—say a tree—will require a certain total area of leaf for the manufacture of the

requisite amount of plant-food. If we cut the branch of a horse chestnut and of a beech where each had exactly a diameter of one inch, or two, or six inches, and counted and measured the leaves on each, while the number of beech leaves would immensely exceed the number of chestnut leaves the total leaf-area would be about the same in each case. This area of green leaf, then, must be spread out to the best advantage. In this connection, a beautiful relation between the shape of leaves and their arrangement on the stem may frequently be remarked. Lay a twig of beech on a sheet of white paper, and note how small are the interstices between the leaves through which the paper may be seen. The shape of the leaves, and the intervals at which they are borne, are so related that an almost continuous expanse of green is offered to the sunlight. A more remarkable case may be seen in the lime, whose leaves are quite inequilateral, being contracted on one side at the base and expanded at the other, in order the more exactly to fill the space which is available. The elm likewise furnishes a beautiful example of close-fitting leaves. In most trees in which, like the beech, hazel, and elm, the leaves lie in close-ranked rows in the same plane as the twig which supports them, we find more or less oval leaves, their breadth varying with the space between the leaves, *i. e.*, the length of the internode. In trees such as the horse chestnut or sycamore, on the other hand, the leaves grow in opposite pairs, and are typically arranged on upright twigs, the leaf-stems projecting at a wide angle from the twig, with the surface of the leaf horizontal. In this

case space is not so curtailed; the leaf is larger, and more or less circular in outline; and the great increase of length in the internodes, as compared with the trees lately considered, prevents a too great overshadowing of the lower leaves by those higher up the shoot.

In plants which have a very short axis—which have in popular language “no stem”—a difficulty arises as to how all the leaves shall receive a due amount of light, since all arise from the same point. This is met in several ways. The leaves are often placed at different angles, the outer leaves, which are the lowest and oldest, spreading horizontally near the ground, the newest rising almost vertically in the centre, the intermediate being disposed at various angles between these extremes. Another solution of the difficulty is effected by a continued growth of the leaf-stalks, each leaf steadily pushing itself outward so that the whole form a slowly expanding circle, in which each leaf-blade successively occupies a position commencing at the centre, ending at the circumference. Such leaf-blades, it is almost needless to say, are widest at the extremity, since that is the portion which receives most light; often the blade is roundish, and placed at the end of a bare leaf-stalk, which pushes it further and further from the centre, as other leaves arise. Such arrangements are well seen in many of our biennial plants. During their first season they form a close leaf-rosette of this kind, which manufactures during the summer and winter a supply of plant food to be stored for the building up of the tall flowering stem of the succeed-

ing year. The stork's-bills, crane's-bills, teazel, and other plants will occur to the reader as examples.

In the case of some plants, the normal position of the blade of the leaf is not horizontal, but vertical. The black poplar and its relation the aspen furnish well-known instances. If we examine the stalk of an aspen leaf we notice that while the lower part of it is circular in section, the part near the leaf is much flattened, permitting free movement in the plane of the leaf-blade. This, together with the position in which the leaves are borne on the twigs, causes the leaves to hang vertically. One result is that the light can stream almost unbroken through the branches even to the ground below, the wealth of foliage producing but a faint tremulous shadow as the leaves rustle in response to every breath of air. Well does Scott, seeking for a simile, say in *Marmion*:

"Variable as the shade
By the light quivering aspen made."

A peculiar point about these vertical leaves should be noted. On the under side of leaves are situated a myriad of tiny openings (*stomata*, mouths) through which the plant absorbs carbon dioxide from the atmosphere, and having taken from it the carbon, liberates the oxygen, the stomata being also used for the escape of the surplus water of the plant. Now, the reason why these mouths are situated in most plants on the under side of the leaves is no doubt because they are thus protected from cold and rain and storm, and their work less interfered with. In the

aspen, with its vertical leaves, either side of which is equally exposed to atmospheric vagaries, there is nothing to choose between the two sides as regards the position of the stomata, and as a matter of fact, these are equally distributed over both sides of the leaf. A further modification of this kind we may find in plants like the water-lily, the leaves of which float on the surface of water. Following out our line of argument, we would expect to find the stomata confined to the *upper* side of such a leaf, so that they may be in contact with the atmosphere, and this is exactly what we do find. Plants whose leaves are all continually below the surface of the water, such as the water lobelia and many pond-weeds, must perforce be content with obtaining the carbon dioxide which they require from the small quantity of that gas which is to be found dissolved in the water.

The protection of leaves against various hurtful agencies next claims our attention. The typical leaf has its upper surface built of strong, closely placed cells, to offer a stout resistance to rain and hail, and to frost or overpowering sun-heat. In hot, dry weather, when great evaporation is taking place, the plant can close up all its stomata—shut down, so to speak, all the sluices by which the water employed to convey dissolved salts from root to leaf is allowed to escape, and thus retain an abundant water supply in spite of parching heat. But in arid ground, such as sandy wastes or sea-beaches, further protection against overtranspiration may be desirable, and this is frequently effected by impervious varnish-like layers on the upper surface of the leaves, or by dense

coverings of hairs. Layers of impermeable corky cells in the epidermis or skin of the leaves are also frequently to be found in plants liable to excessive transpiration. Such impermeable leaves are beautifully developed in plants like the stonecrops, which, growing in dry ground and on rocks, and being liable to long-continued drought, store up in their leaves a copious water supply. Such reservoir-leaves are greatly developed in the plants of desert countries. Protection against the often fatal effect of frost is likewise afforded by a thickening of the cuticle of leaves, and especially by felt-like coverings of hairs. In some noteworthy cases protection against cold is effected by means of movement on the part of the leaves. The most familiar examples occurring among our native plants are furnished by the trifoliate leaves of many of the clover family. As evening approaches, the clovers and their allies fold their three leaflets together by means of an upward movement; the juxtaposition of the leaflets retards loss of heat, and the vertical position which they thus assume has the same effect, tending to check the radiation of heat to the cold sky overhead. The wood sorrel, which, though of a quite different order, has leaves which resemble those of the clovers, effects the same object by folding its leaflets *downward*.

Wet, which by lying on the leaves might hinder transpiration, must also be guarded against; a danger which in many species is obviated by means of a waxy excretion, especially on those parts of the leaves where the stomata are situated; on which, as on an oily surface, water will not lie.

Another danger to which plants are exposed, and one which we might think they would be powerless to meet, is the attacks of browsing animals—animals of all sizes, from minute insects up to great munching cattle. But to note how perfectly such defence may be provided for we need only look at our common gorse, which boldly invades the pasture, protected by its impenetrable chevaux-de-frise. This plant, indeed, seems to have put so much of its vital energy into the production of spines that it has none left with which to produce leaves, and the making of plant-food has to be carried on by the green and much-branched stems. The beautiful tribe of the thistles naturally comes to our minds in this connection. Armed with innumerable spines of the most exquisite structure, sharper and more delicate far than needles, the spear thistle and marsh thistle raise their tall and graceful forms untouched amid the close-browsed herbage, and without fear of molestation—save from man, with his implements of iron—open their flower-heads to the sun and the insects, and scatter their numberless winged fruits to the wind. In the thistle the spines are borne alike on the stems, leaves, and involucre or outer whorls of the heads of flowers. The holly is an interesting case. In low bushes the edges of the leaves are provided with strong spines; but when the bush grows into a tree, and bears leaves far above the reach of browsing animals, the unnecessary spines disappear, and the edges of the leaves are entire. In the blackthorn and hawthorn, the strong spines are modified branches; and we may observe that they are much more numerous

in young plants than in old bushes. A more complicated mode of protection is found in the nettles. They are furnished with hollow hairs, filled with a virulent fluid, and bent at the tip. A slight pressure causes the curved extremity to break across, leaving a slender tube, tapering to an extremely fine point, which easily enters the flesh and discharges a portion of its venomous contents.

So far we have considered leaves as fulfilling their normal functions of producing plant-food by means of chlorophyll cells. In conclusion, brief reference may be made to various exceptions; for the production of plant-food is not necessarily carried on by leaves, nor is the use of leaves altogether limited to the production of plant-food. First, leaves may be dispensed with, as we have already seen in the case of the gorse. The stem may be modified to supply the place of leaves, as in the butcher's broom, whose flattened "leaves" are really branches, as we see when we find flowers and fruit borne on these flat leaf-like structures.

In climbing plants the leaves, or a portion of them, are frequently converted into tendrils, often endowed with a marvelous sense of touch, for grasping supports and thus aiding the plant in its upward climb through surrounding herbage to the light. This is seen in many of the vetches, the upper end of whose leaves are modified in this fashion. In the yellow vetchling (*Lathyrus aphaca*) a further modification has taken place. The whole leaf is converted into a tendril, while the stipules (the usually small pair of leaf-like appendages that often grow at

the point where a leaf joins a stem) are enlarged into a very respectable pair of "leaves," and manufacture food while the true leaf helps the plant to climb.

WIND-FERTILIZED FLOWERS

—ALEXANDER S. WILSON

AS an agent in cross-fertilization, the wind performs an indispensable service to many plants. Flowers which depend on its agency for the transport of their pollen are termed anemophilous; those adapted to insects, entomophilous. Wind-fertilized blossoms are all of small size, obscurely colored, and, even when clustered together in catkins, inconspicuous; hence they escape observation more readily than their entomophilous neighbors, which are adorned with bright colors to allure visitors. Although anemophilous flowers do not exhibit the variety of curious contrivances found in the entomophilous class, they yet present a number of highly interesting characters, and are well worthy of examination. Wind-fertilization is universal in the lower or gymnospermous division of flowering plants, of which we have examples in the pine, larch, cedar, and other coniferous trees. The apetalous dicotyledons or Incompletæ form another large group in which wind-fertilization prevails extensively.

In this sub-class are included the various species of dock, sorrel, nettle, pellitory of the wall, dog's mercury, goosefoot, boxwood, hop, mulberry, elm, and catkin, bearing trees such as the oak, hazel, beech, poplar, birch, alder, walnut, and willow, all

of which are wind-fertilized. Anemophily is not so common in dicotyledons belonging to the subclasses; it occurs, however, in the ash, plantain, wormwood, mare's-tail, and meadow-rue. The number of wind-fertilized monocotyledons far exceeds those adapted to insects, both as regards individuals and species. The extensive order of grasses, the sedges, carices, and rushes, together with the arrow-head, arrowgrass, bur-reed, and bulrush, are all without exception anemophilous. It thus appears that wind-fertilization occurs in many different and widely separated families. Certain negative characters are common to all the wind-fertilized class; no honey is secreted, no perfume emitted, and conspicuous colors are wanting. On flowers of this description it is difficult for a large insect like a bee to obtain a footing; there is no corolla that can serve as a landing-stage for insects to alight. For these reasons anemophilous blossoms are almost entirely neglected by bees and other flower-hunting insects; only in exceptional instances do visitors have recourse to them in search of pollen, but this is so dry and has so little cohesion that it must be difficult indeed for a bee to collect an appreciable quantity of anemophilous pollen. Wind-fertilized flowers thus offer little or no attraction to insects, and are in no way adapted to derive benefit from their visits. On the other hand, there exists in them a number of provisions which admirably adapt them for cross-fertilization through atmospheric agency. The most important of these is abundant pollen; always more than in insect-fertilized blossoms, the quantity pro-

duced by some plants of the wind-fertilized class is enormous. The so-called showers of sulphur, occasionally reported in the newspapers, are really great deposits of pollen blown from the male cone of the Scotch fir. It has been known to fall on ships at sea, and has been swept up in bucketsful from their decks. The common ash discharges an immense quantity from its innumerable flowers, so much so that a person shaking a branch when the tree is in bloom is dusted from head to foot with the dry, powdery pollen. That of the elm is also very abundant, and this is more or less characteristic of all plants which depend for cross-fertilization on the wind. At certain seasons, the air may be said to be literally charged with the pollen of anemophilous plants. In the beginning of May, I exposed on the window-sill for forty-eight hours a microscopic slide smeared with syrup, and on examining it afterward detected upward of fifty pollen-grains belonging to various trees, some of which are not to be found within a radius of two miles. The efficiency of the wind as a fertilizing agent is, therefore, much greater than one might suppose.

The pollen grains of insect-fertilized flowers are frequently, as in the harebell, colt's-foot, and mallow, studded over with little projecting points; these cause them to adhere readily to each other or to the hairs of an insect. In other cases the pollen is viscid, and the granules are difficult to separate. This cohesive character obviously renders them ill adapted for transference by means of the wind; accordingly, the pollen of wind-fertilized plants is excessively light

and dry, the granules are smooth, they do not stick together, and this incoherence facilitates their wide dispersion. A special provision exists in the pine, whereby its pollen is rendered lighter and more easily wafted by the wind; the extine or outer membrane of each granule is inflated into two globular air-sacs, which reduce its specific gravity so that it can keep longer afloat in the air.

Although there are wind-fertilized species to be found in bloom all the year round, a large number, especially of trees, blossom early in the season; the hazel comes into bloom in February, the elm, poplar, and willow following in March or April. The little flowers of the willow are already developed within the bud at the beginning of winter; in spring they merely expand. It is, therefore, probable that trees of this class originally flowered toward the end of the year, but ultimately became so belated that the opening of their flowers had to be delayed over winter. During the dry, windy days of spring, when the farmer sows his seed-corn, the flowers of our anemophilous trees are in perfection. At this early period, when so few insects are abroad, these unattractive blossoms are not likely to be visited.

A marked peculiarity of anemophilous trees is the appearance of the flowers before the foliage; the blossoms of the elm, poplar, ash, and willow, for example, are put forth while as yet the branches are entirely leafless. This arrangement is clearly advantageous; the foliage would protect the flowers from the wind, preventing its gaining access to the stigmas and interfering with the removal of the pollen.

The fir does not shed its leaves in autumn, as deciduous trees do, but its needle-like foliage interferes as little as possible in the way indicated; nevertheless, the male and female cones are developed on the branches of the fir in the most exposed positions. A good illustration of the manner in which wind-fertilized plants secure the exposure of their blossoms is seen in the dog's-mercury (*Mercurialis perennis*). This plant, common in most districts, has rather large leaves; they expand before the flowers, and would be a great hindrance to wind-fertilization were it not that the little staminate flowers are elevated on long, slender stalks which spring from the axils of the leaves and entirely overtop the foliage. The male catkin of the oak is an inflorescence of the same description, not erect, however, but pendulous, and so flexible that it swings freely in the lightest breeze. After the flowering period, the ground under the oak, poplar, and other trees is strewn with their male catkins; these are caducous, falling off soon after they have shed their pollen; the catkins of female flowers are necessarily persistent, though a few may occasionally be broken off by the violence of the wind.

In reeds and grasses, the entire plant, being flexible, is easily shaken by the wind, and the ripe pollen is readily dislodged from the anthers; but where the stem is more rigid either the flower stalks are slender or the stamens have thin, thread-like filaments; or the entire inflorescence is mobile; in any case provision is made in the structure of the flower for the agitation of the anthers by the wind. Slender

flower stalks are seen in the dock and in the quaking grass (*Briza*). The ribwort plantain (*Plantago lanceolata*) and a great many grasses have their anthers borne on long, excessively thin stalks, so that they quiver in the slightest breeze. Broad and leaf-shaped, the anther itself in *plantago* is clearly adapted, like the seed-vessels of some crucifers, to be set in motion by the wind. On a calm and warm day in summer the gentlest touch is sufficient to make many grasses, such as the foxtail, cock's-foot or timothy, emit a little cloud of pollen. Some grasses even appear to eject the pollen with force either by the explosion of the pollen-sacs or by a sudden jerking of the stamens. The nettle and pellitory have each four elastic stamens; when the flower opens, these are bent inward toward the centre in a constrained position; later on the tension is removed and the liberated stamens suddenly straighten out, scattering their pollen like little puffs of smoke. The object of this liliputian artillery is to throw the pollen away quite clear of the plant by which it was produced.

Petals in ordinary flowers are intended to secure the attention of insects; to wind-fertilized blossoms, having no occasion for visitors, they are unnecessary. So far from an advantage, the presence of a corolla would exclude the wind from the essential organs. Accordingly, petals are either absent altogether or reduced to rudimentary proportions. The calyx is also much reduced, and in some flowers is dispensed with entirely. Comparatively few anemophilous flowers possess both sets of floral envelopes. *Plantago*

is, however, dichlamydeous, but its chaffy petals afford incontrovertible evidence of degeneration from the entomophilous condition.

The stigma in the wind-fertilized class is highly specialized, and much larger relatively to the other parts of the flower than is the case with entomophilous blossoms. It is commonly penicillate, consisting of a tuft of hairs, as in nettle; feathery, as in grasses; or elongated and threadlike, as in plantago and the rushes. The spirally twisted stigmas of the last-mentioned flowers are beautiful objects when examined with a pocket lens. The larger the surface which the stigma presents to the wind, the greater are the chances of pollination. Its fine fringes of papillose hairs are also well calculated to entangle the pollen-grains, while the viscid secretion serves to retain them when caught. This adaptation may be seen in the common rye grass; each tiny blossom as it expands hangs out its two white, feathery stigmas from the sides of the spikelet, reminding one of a fisherman spreading out his nets, or a sailor his studding sails to catch the favoring breeze. At the time of fertilization the dock, too, thrusts out its three little brush-like stigmas between the lobes of the perianth. It is instructive to compare these wind-fertilized flowers of *Rumex* with those of the nearly allied genus *Polygonum*, which is entomophilous. The perianth of the latter is rose-colored; the stigmas are included within it, never exserted as in the dock—they are not at all brush-like or feathery, but in the form of little knobs; the stamens and flower-stalks are rigid;

moreover, the various species of *Polygonum* secrete nectar and are frequented by many different insects. Stigmas are entirely absent in the gymnospermous division, but in most Coniferæ the ovule at the time of flowering secretes a drop of liquid, and the pollen-grains caught on it are, as the fluid gradually evaporates, stranded on the nucleus of the ovule. The ovule of the larch is provided with elongated papillæ, functionally equivalent to a stigma.

A flower is said to be hermaphrodite or monoclínous when, as in the elm, both stamens and pistils are present in the same blossom. With insect-fertilized flowers this is mostly the case, though there are some exceptions, such as the cucumber and begonia, which are unisexual or diclínous, stamens and pistils being produced in separate blossoms. The diclínous condition is exceedingly common in the wind-fertilized class. The staminate or male, and the pistillate or female, flowers are sometimes found growing on the same individual plant, which is then termed monœcious, as in the oak, hazel, birch, pine, etc. The poplar, willow, yew, juniper, nettle, and dog's-mercury, on the other hand, are diœcious; their staminate and pistillate flowers grow on separate plants. This separation of the sexes renders self-fertilization impossible, and secures whatever benefit may arise from the physiological division of labor. Anemophilous species in general show a marked tendency in the direction of separation. Self-fertilization may be prevented in monoclínous flowers by the stamens and stigmas maturing at different times. This arrangement, known as dichog-

amy, occurs in both insect and wind-fertilized blossoms, but while the former usually have the stamens in advance of the stigmas, in the latter the reverse order is much more frequent. There are thus two kinds of dichogamy—protandrous, when the stamens are in advance; protogynous, if the pistils are first developed. Protogyny is characteristic of wind-fertilized flowers, and may be easily observed in the rush and plantain. In the first or female stage of the flower of the rush, the thread-like stigma protrudes from the top of the still unopened perianth, while the stamens, as yet immature, are completely concealed. In the second stage, the pollinated stigmas have begun to shrivel, the perianth has now spread out, disclosing the six stamens which are ready to discharge their pollen. The same two stages are equally apparent in plantago. All our readers must be familiar with the black heads of this plant, which are to be seen in every pasture, bending and waving in the wind. In the first stage, the head appears black, but on looking into it we see projecting from each little unopened floret a white thread-like stigma. Later on, the lower part of the spike or head is seen to be encircled by a wreath of tiny white bodies, and closer inspection shows that these are the stamens, four of which project like little banners from each of the newly opened florets. The protogynous character belongs in the bur-reed to the plant itself rather than the individual flowers. Its pistillate flowers, which are lowermost, expand first; only when their stigmas have withered do the male florets higher up begin discharging their pol-

len. In this case, it is evident that the flowers on any plant must be fertilized with pollen from another in more advanced condition. A social habit is highly characteristic of wind-fertilized plants—pines, grasses, sedges, nettles, etc., usually grow together in considerable numbers. Entomophilous plants have a much more sporadic character, and admit of a greater degree of isolation; their guests, doubtless, maintain the necessary communication between members of the species. This social habit partly explains the tendency toward the diœcious condition, for a complete separation of the sexes is hardly possible, except in plants of social habit. From the gymnosperms, the oldest flowering plants, being all wind-fertilized, it has been inferred that such must also have been the case with the primitive angiosperms. It is not certain, however, that any of their representatives remain, for many of our existing wind-fertilized flowers appear to be merely degraded forms. Anemophilous species appear in families, the rest of which are highly specialized in relation to insects. Some species of plantago are adapted to insects; others, as we have seen, to the wind. Most of the sub-classes with incomplete flowers, from which so many of our examples are taken, also exhibit striking marks of degeneration, and the same may be said of the grasses and other anemophilous monocotyledons. We also find some flowers in an intermediate condition, such as the vine and certain willows, which secrete honey and are visited by insects. Facts of this description are held by some to show that all existing anemophilous spe-

cies, with the exception of the gymnosperms, are descended from bright-colored, insect-fertilized ancestors.

Wind-fertilization has, in some instances, been rendered highly efficient, but in any case it is far from economical, for the vast amount of pollen mis-carried represents an enormous loss to plants; neither does this method admit of the same certainty and precision as the other. A wind-fertilized bears to an insect-fertilized blossom very much the relation which an æolian harp bears to a pianoforte.

MOVEMENTS OF PLANTS

—DAVID ROBERTSON

SCARCELY any one can have failed to notice that many plants close their flowers when evening approaches, others again at various periods of the day, while some close their flowers when the sky is overcast; foliage leaves also are in many cases subject to periodic movements.

The movements of different plants are dependent on various causes.

Some of these movements are solely mechanical, and caused by the tissues being affected, owing to the condition of the surrounding air and to varying states of turgidity and exhaustion.

Other movements are apparently due to physical causes, but can not be fully explained by attributing them to these causes.

Movements in plants also depend upon the contractile quality of the protoplasm in the cells, and on

the passage of the protoplasm from cell to cell. The property of the protoplasm gives rise to movements caused by the plant itself, which are not at least directly due to any external exciting cause. These movements can be compared with the movements of the lower animals, and to the ciliary motion found in certain tissues belonging to the most highly organized animals.

The periodic movements, such as the "waking" and "sleeping" condition of leaves, the closing of flowers, etc., are manifested only when the organs are fully matured, and when the peculiarity of their internal structure which gives rise to the phenomena of periodic movements is fully developed.

These movements are to be carefully distinguished from those due to unequal growth, such as movements of nutation. In this case there is no special structure upon which the movements depend.

The bursting of seed-vessels, anthers, etc., is due partly to the fact that the condition of the tissues, as regards the amount of liquid they contain from their possessing unequal power of imbibing moisture, is not equally elastic. For this reason, when the less elastic portions of tissue are subjected to strain they are torn apart or bent in various ways, owing to unequal contractions and expansions, caused by an access or withdrawal of moisture.

These cases can scarcely be regarded as vital phenomena, but should rather come under the category of what is in ordinary language named "warping." They are simply caused by particular modes of the destruction of dead tissue due to conditions brought

about by variations in the structure of the tissues in question.

Movements in plants which take place periodically, such as sleeping and waking, or those movements that take place when they are touched or otherwise affected by certain kinds of exciting stimulus, can not be attributed to mechanical causes. The slightest mechanical stimulus on the sensitive plant *Mimosa pudica* causes the leaflets to fold together. Such movements are not proportional to the external stimulus, but depend on the internal structure of the plant.

To this class of movements have been added the very remarkable movements which give rise to the twining condition of certain stems.

Another class of movements may be mentioned, viz., movements of the protoplasm in cells, or movements of free bodies, such as zoospores (Greek, *zoon*, animal, and *spora*, seed), antherozoids (Greek, *anthos*, flower; *zoon*, animal; *eidos*, form), and sometimes even perfect individuals, such as *Desmediæ*, etc., which may have the power of temporary or permanent locomotion.

The rotation of the protoplasm of cells is attributed to causes similar to those which produce locomotion in the simpler plants, and these movements are strikingly like some of the movements of the protozoa in the animal kingdom. The movements of the products of cell contents having no cell-wall, such as zoospores and antherozoids, are generally caused by the rapid movement of cilia (plural of the Latin word *cilium*, an eyelid) or small filaments which

cover the surface. The locomotion of certain plants, such as *Diatomaceæ*, is apparently not due to cilia.

Sensitive plants, such as the *Mimosa pudica*, are strongly affected by any mechanical stimulus, and thus afford us examples of the phenomenon named "irritability."

The sleep of plants is most probably a case of irritability, and differs only in degree, not in kind.

Sensitiveness in plants is affected both by light and heat. It has been experimentally proved that sensitive plants, if kept in the dark, lose their sensibility after a period of seven days, and actually die after twelve days.

We know that white light is composed of light of different colors. Light is propagated in waves, and each color is distinguished by having a different wave-length from that of any other color. Red light differs, for example, from violet light in the length of its waves, and violet light differs from blue, etc.

It is, therefore, not surprising to find that the different colored rays are capable of producing different effects. It has been ascertained that under the influence of green light sensitive plants die after sixteen days' exposure, though they retain their sensibility for twelve days.

When the plants were exposed to violet and blue light, their growth completely ceased. They, however, retained their vitality as well as their sensibility for three months. The effect of heat on sensitive plants has also been ascertained.

The sensitiveness and periodical movements of *Mimosa* do not begin till the temperature of the sur-

rounding air exceeds 15° C. The periodical movements of the lateral leaflets of the Indian telegraph plant (*Desmodium gyrans*) can only occur when the temperature exceeds 22° C.

When the temperature of the air is 40° C., the leaves become stiff in less than an hour, and at 48° C. to 50° C. rigidity takes place within a few minutes; but when the temperature falls, the sensitiveness may again be manifested.

A temperature of 52° C. not only causes loss of permanent motion, but also the death of the plant.

The mechanism to which the periodic movements of plants is due is not by any means fully known.

The particular circumstances which regulate the turgidity have not been, so far, determined with precision.

It has, however, been clearly ascertained that this turgid state is associated with the passage of fine threads or filaments of protoplasm from one cell to another, and at the same time with an accumulation of a soluble chemical compound named glucose, a kind of sugar, in fact. This substance possesses great osmotic power; that is, it can pass very rapidly through the flexible cell-walls of the pulvinus forming the so-called springs. These movements are, therefore, closely connected with the rapid absorption and expulsion of liquid.

Contrary to the habit of most plants, the sensitive plant raises its leaves at night and closes them by day.

The most usual kind of movement in these plants is that in which the leaves as well as the floral en-

velopes assume the position they occupied before the buds opened.

Compound leaves, such as the leaves of the Leguminosæ, or pea-family, exhibit a simple or compound movement.

The leaves of the bean fold upward, those of the *Lupinus* fold downward. In *Tamarinds* the leaves fold to the side. In some other plants the common petiole of the compound leaves become raised or depressed, while the leaflets turn downward or side-wise. This is the case in *Amorpha fruticosa* and *Gleditschia tracanthus*.

In the well-known *Mimosa pudica*, which is a hot-house plant in temperate regions, the leaflets fold together, the small stalks of the leaflets of the compound leaves of this plant approach each other, and the main petiole becomes depressed.

In one exceedingly sensitive species of *Oxalis*, the pinnate leaves fold upward. A footfall is said to be sufficient to cause it to close its leaves.

When these movements of leaves or leaf-organs take place at stated hours, and when the leaves remain in the new position after the movement has ceased until a particular period of time recur, the closing up is called the *sleep* of plants. This condition is observed both in seed-leaves and true leaves, as well as in the petals of flowers.

So far as can be made out, the object of this closing of the leaves seems to be to prevent the chilling effect due to radiation from being injurious to the plant. This folding up causes a smaller extent of surface to be exposed. Radiation of heat during a clear night

goes on rapidly from all surfaces such as those of expanded leaves. The closing of the leaves may be supposed to form a protective covering, which prevents the heat passing away into space, and thus saves the plant from the injurious effects of cold.

This is only true of the foliage leaves, which expand during the day and close during the night.

The period at which the movement of closing and opening of flowers takes place is very varied. Ordinary leaves, as has been stated, close toward evening and open in the day. The periods of opening and closing in the case of flowers vary considerably, being affected, no doubt, by the visits of insects, which carry the pollen from plant to plant belonging to the same species. By this means flowers are fertilized, and the seeds resulting from plants that are so fertilized are much more numerous than those resulting from self-fertilized plants. Some plants, such as the pimpernel, close their petals when the sky is overcast. This is doubtless to protect the pollen from the injurious effects of rain. This kind of closing, however, is not to be confounded with the regular and periodic closing and opening of flowers.

The diversity in the regular and periodic opening and closing of flowers in regard to time is so great that Linnæus was able to arrange flowers in a list in accordance with their times of opening and closing.

This list he named a *Horologium floræ*, or floral clock, the time of opening or closing representing each succeeding hour.

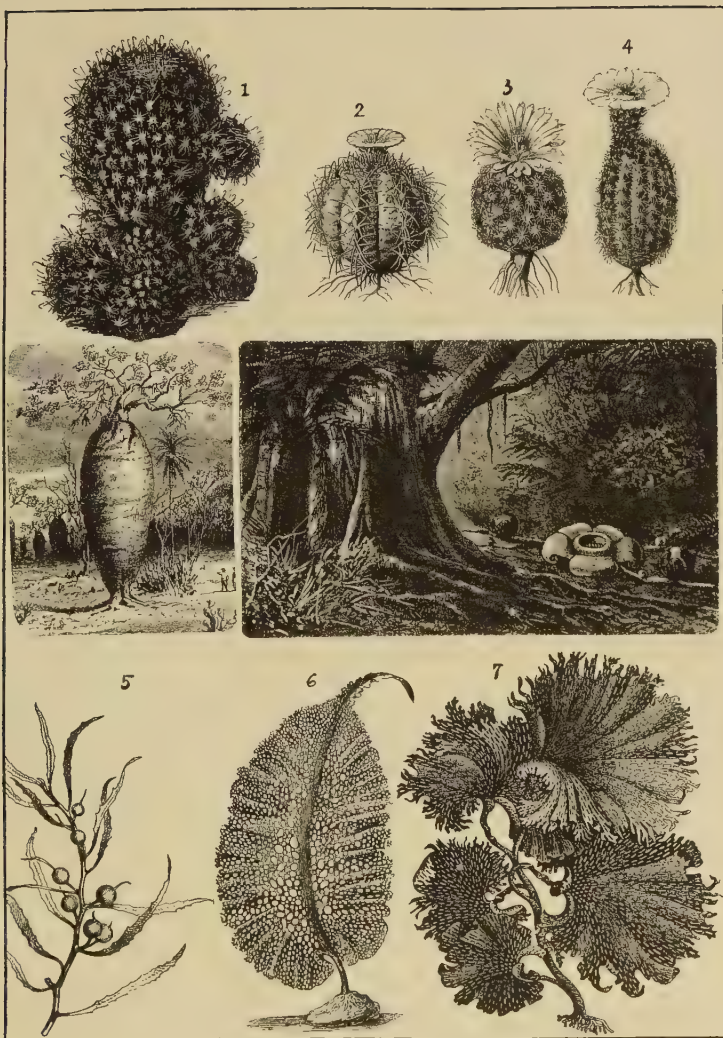
Some closing flowers open under the influence of strong artificial light, such, for example, as *Crocus*

and *Gentiana verna*; on others, however, such as *Convolvulus*, artificial light has no effect.

The closing of flowers is usually a slow process, as may easily be observed, but there are exceptions to this.

"In *Desmodium gyrans*" (the Indian telegraph-plant) "the trilobate compound leaf has a large terminal leaflet and a smaller one on each side. When the plant is exposed to bright sunlight in a hot-house, the end leaflet stands horizontally, and it folds downward in the evening, but the lateral leaflets move constantly during the heat of the day, advancing, edgewise, first toward the end leaflet, and then returning and moving toward the base of the common petiole alternately on each side, in a manner very well compared to the movements of the arm of the old semaphore telegraphs."

Such are some of the more striking movements of plants. Even in cases where the precise advantage, as far as regards the economy of plant life, is not fully ascertained, it can not be doubted that such movements are advantageous. In strict accordance with the accepted theory of evolution, no peculiarity would be continued from generation to generation of either plants or animals, if it possessed no essential characteristic which helped the plant or animal to hold its own in "the struggle for existence."



Cacti, Rare Flowers, and Fuci

Cacti—1 and 3, Mamillaria; 2, Echinocactus; 4, Cereus. Fuci—5, Sargassum; 6, Agarum; 7, Thalassophyllum. The Wool Tree (*Bombax*) and the *Rafflesia Arnoldi*

MOVEMENT IN PLANTS

—CHARLES DARWIN

PLANTS become climbers in order, it may be presumed, to reach the light and to expose a large surface of leaves to its action and to that of the free air. This is effected by climbers with wonderfully little expenditure of organized matter, in comparison with trees, which have to support a load of heavy branches by a massive trunk. Hence, no doubt, it arises that there are in all quarters of the world so many climbing plants belonging to so many different orders. These plants are here classed under three heads. First, hook-climbers, which are, at least in our temperate countries, the least efficient of all, and can climb only in the midst of an entangled vegetation. Secondly, root-climbers, which are excellently adapted to ascend naked faces of rock: when they climb trees, they are compelled to keep much in the shade; they can not pass from branch to branch, and thus cover the whole summit of a tree, for their rootlets can adhere only by long-continued and close contact with a steady surface. Thirdly, the great class of spiral climbers, with the subordinate divisions of leaf-climbers and tendril-bearers, which together far exceed in number and in perfection of mechanism the climbers of the two previous classes. These plants, by their power of spontaneously revolving and grasping objects with which they come in contact, can easily pass from branch to branch, and securely wander over a wide and sunlit surface. I

have ranked twiners, leaf and tendril-climbers as subdivisions of one class, because they graduate into each other, and because nearly all have the same remarkable power of spontaneously revolving. Does this gradation, it may be asked, indicate that plants belonging to one subdivision have passed, during the lapse of ages, or can pass, from one state to the other; has, for instance, a tendril-bearing plant assumed its present structure without having previously existed either as a leaf-climber or a twiner? If we consider leaf-climbers alone, the idea that they were primordially twiners is forcibly suggested. The internodes of all, without exception, revolve in exactly the same manner as twiners; and some few can twine as well, and many others in a more or less imperfect manner. Several leaf-climbing genera are closely allied to other genera which are simple twiners. It should be observed that the possession by a plant of leaves with their petioles or tips sensitive, and with the consequent power of clasping any object, would be of very little use, unless associated with revolving internodes, by which the leaves could be brought into contact with surrounding objects. On the other hand, revolving internodes, without other aid, suffice to give the power of climbing, so that, unless we suppose that leaf-climbers simultaneously acquired both capacities, it seems probable that they were first twiners, and subsequently became capable of grasping a support, which, as we shall presently see, is a great additional advantage.

From analogous reasons, it is probable that tendril-bearing plants were primordially twiners—that is,

are the descendants of plants having this power and habit. For the internodes of the majority revolve, like those of twining plants; and, in a very few, the flexible stem still retains the capacity of spirally twining round an upright stick. With some the internodes have lost even the revolving power. Tendril-bearers have undergone much more modification than leaf-climbers; hence it is not surprising that their supposed primordial revolving and twining habits have been lost or modified more frequently than with leaf-climbers. The three great tendril-bearing families in which this loss has occurred in the most marked manner are the Cucurbitaceæ, Passifloraceæ, and Vitaceæ. In the first the internodes revolve; but I have heard of no twining form, with the exception of *Mormodica balsamina*, and this is only an imperfect twiner. In the other two families I can hear of no twiners; and the internodes rarely have the power of revolving, this power being confined to the tendrils; nevertheless, the internodes of *Passiflora gracilis* have this power in a perfect manner, and those of the common vine in an imperfect degree: so that at least a trace of the supposed primordial habit is always retained by some members of the larger tendril-bearing groups.

On the view here given, it may be asked, Why have nearly all the plants in so many aboriginally twining groups been converted into leaf-climbers or tendril-bearers? Of what advantage could this have been to them? Why did they not remain simple twiners? We can see several reasons. It might be an advantage to a plant to acquire a thicker stem,

with short internodes bearing many or large leaves; and such stems are ill fitted for twining. Any one who will look during windy weather at twining plants will see that they are easily blown from their support; not so with tendril-bearers or leaf-climbers, for they quickly and firmly grasp their support by a much more efficient kind of movement. In those plants which still twine, but at the same time possess tendrils or sensitive petioles, as some species of *Bignonia*, *Clematis*, and *Tropæolum*, we can readily observe how incomparably more securely they grasp an upright stick than do simple twiners. From possessing the power of movement on contact, tendrils can be made very long and thin; so that little organic matter is expended in their development, and yet a wide circle is swept. Tendril-bearers can, from their first growth, ascend along the outer branches of any neighboring bush, and thus always keep in the full light; twiners, on the contrary, are best fitted to ascend bare stems, and generally have to start in the shade. In dense tropical forests, with crowded and bare stems, twining plants would probably succeed better than most kinds of tendril-bearers; but the majority of twiners, at least in our temperate regions, from the nature of their revolving movement, can not ascend a thick trunk, whereas this can be effected by tendril-bearers, if the trunks carry many branches or twigs; and in some cases they can ascend by special means a trunk without branches, but with a rugged bark.

The object of all climbing plants is to reach the light and free air with as little expenditure of or-

ganic matter as possible; now, with spirally ascending plants, the stem is much longer than is absolutely necessary; for instance, I measured the stem of a kidney-bean which had ascended exactly two feet in height, and it was three feet in length: the stem of a pea, ascending by its tendrils, would, on the other hand, have been but little longer than the height gained. That this saving of stem is really an advantage to climbing plants I infer from observing that those that still twine, but are aided by clasping petioles or tendrils, generally make more open spires than those made by simple twiners. Moreover, such plants very generally, after taking one or two turns in one direction, ascend for a space straight, and then reverse the direction of the spire. By this means they ascend to a considerably greater height, with the same length of stem, than would otherwise be possible; and they can do it with safety, as they secure themselves at intervals by their clasping petioles.

Tendrils consist of various organs in a modified state, namely, leaves and flower-peduncles, and perhaps branches and stipules. The position alone generally suffices to show when a tendril has been formed from a leaf; and in *Bignonia* the lower leaves are often perfect, while the upper ones terminate in a tendril in place of a terminal leaflet; in *Eccremocarpus* I have seen a lateral branch of a tendril replaced by a perfect leaflet; and in *Vicia sativa*, on the other hand, leaflets are sometimes replaced by tendril-branches; and many other such cases could be given. But he who believes in the slow

modification of species will not be content simply to ascertain the homological nature of different tendrils; he will wish to learn, as far as possible, by what steps parts acting as leaves or as flower-peduncles can have wholly changed their function, and have come to serve as prehensile organs.

In the whole group of leaf-climbers abundant evidence has been given that an organ, still subserving its proper function as a leaf, may become sensitive to a touch, and thus grasp an adjoining object. In several leaf-climbers true leaves spontaneously revolve; and their petioles, after clasping a support, grow thicker and stronger. We thus see that true leaves may acquire all the leading and characteristic qualities of tendrils, namely, sensitiveness, spontaneous movement, and subsequent thickening and induration. If their blades or laminæ were to abort, they would form true tendrils. And of this process of abortion we have seen every stage; for in an ordinary tendril, as in that of the pea, we can discover no trace of its primordial nature; in *Mutisia clematis*, the tendril in shape and color closely resembles a petiole with the denuded midribs of its leaflets; and occasionally vestiges of laminæ are retained or reappear. Lastly, in four genera in the same family of the *Fumariaceæ* we see the whole gradation; for the terminal leaflets of the leaf-climbing *Fumaria officinalis* are not smaller than the other leaflets; those of the leaf-climbing *Adlumia cirrhosa* are greatly reduced; those of the *Corydalis claviculata* (a plant which may be indifferently called a leaf-climber or tendril-bearer) are either reduced to

microscopical dimensions or have their blades quite aborted, so that this plant is in an actual state of transition; and, finally, in the *Dicentra* the tendrils are perfectly characterized. Hence, if we were to see at the same time all the progenitors of the *Dicentra*, we should almost certainly behold a series like that now exhibited by the above-named four genera. In *Tropæolum tricolorum* we have another kind of passage; for the leaves which are first formed on the young plant are entirely destitute of laminæ, and must be called tendrils, while the later formed leaves have well-developed laminæ. In all cases, in the several kinds of leaf-climbers and of tendril-bearers, the acquirement of sensitiveness by the midribs of the leaves apparently stands in the closest relation with the abortion of their laminæ or blades.

On the view here given, leaf-climbers were primordially twiners, and tendril-bearers (of the modified leaf division) were primordially leaf-climbers. Hence leaf-climbers are intermediate in nature between twiners and tendril-bearers, and ought to be related to both. This is the case: thus the several leaf-climbing species of the *Antirrhineæ*, of *Solanum*, of *Cocculus*, of *Gloriosa* are related to the other genera in the same family, or even to other species in the same genus, which are true climbers. On the other hand, the leaf-climbing species of *Clematis* are very closely allied to the tendril-bearing *Naravelia*: the *Fumariaceæ* include closely allied genera which are leaf-climbers and tendril-bearers. Lastly, one species of *Bignonia* is both a leaf-climber and a

tendrill-bearer, and other closely allied species are twiners.

Tendrils of the second great division consist of modified flower-peduncles. In this case likewise we have many interesting transitional states. The common vine (not to mention the *Cardiospermum*) gives us every possible grade from finely developed tendrils to a bunch of flower-buds, bearing the single usual lateral flower-tendrill. And when the latter itself bears some flowers, as we know is not rarely the case, and yet retains the power of clasping a support, we see the primordial state of all these tendrils which have been formed by the modification of flower-peduncles.

According to Mohl and others, some tendrils consist of modified branches. I have seen no such case, and, therefore, of course, know nothing of any transitional states, if such occur. But *Lophospermum*, at least, shows us that such a transition is possible; for its branches spontaneously revolve, and are sensitive to contact. Hence, if the leaves of some of the branches were to abort, they would be converted into true tendrils. Nor is it so improbable as may at first appear that certain branches alone should become modified, the others remaining unaltered; for with certain varieties of *Phaseolus* some of the branches are thin and flexible and twine, while other branches on the same plant are stiff and have no such power.

If we inquire how the petiole of a leaf, or the peduncle of a flower, or a branch first becomes sensitive and acquires the power of bending toward the

touched side, we get no certain answer. Nevertheless, an observation by Hofmeister well deserves attention, namely, that the shoots and leaves of all plants, while young, move after being shaken; and it is almost invariably young petioles and young tendrils, whether of modified leaves or flower-peduncles, which move on being touched; so that it would appear as if these plants had utilized and perfected a widely distributed and incipient capacity, which capacity, as far as we can see, is of no service to ordinary plants. If we further inquire how the stems, petioles, tendrils, and flower-peduncles of climbing plants first acquired their power of spontaneously revolving or, to speak more accurately, of successively bending to all points of the compass, we are again silenced, or at most can only remark, that the power of movement, both spontaneous and from various stimuli, is far more common with plants, as we shall presently see, than is generally supposed to be the case by those who have not attended to the subject. There is, however, one remarkable case of the *Maurandia semperflorens*, in which the young flower-peduncles spontaneously revolve in very small circles, and bend themselves, when gently rubbed, to the touched side; yet this plant certainly profits in no way by these two feebly developed powers. A rigorous examination of other young plants would probably show some slight spontaneous movement in the peduncles and petioles, as well as that sensitiveness to shaking observed by Hofmeister. We see at least in the *Maurandia* a plant which might, by a little augmentation of qual-

ities which it already possesses, come first to grasp a support by its flower-peduncles (as with *Vitis* or *Cardiospermum*) and then, by the abortion of some of its flowers, acquire perfect tendrils.

There is one interesting point which deserves notice. We have seen that some tendrils have originated from modified leaves, and others from modified flower-peduncles; so that some are foliar and some axial in their homological nature. Hence it might have been expected that they would have presented some difference in function. This is not the case. On the contrary, they present the most perfect identity in their several remarkable characteristics. Tendrils of both kinds spontaneously revolve at about the same rate. Both, when touched, bend quickly to the touched side, and afterward recover themselves and are able to act again. In both the sensitiveness is either confined to one side or extends all round the tendril. They are either attracted or repelled by the light. The tips of the tendrils in these two plants become, after contact, enlarged into disks, which are at first adhesive by the secretion of some cement. Tendrils of both kinds, soon after grasping a support, contract spirally; they then increase greatly in thickness and strength. When we add to these several points of identity the fact of the petiole of the *Solanum jaspinoïdes* assuming the most characteristic feature of the axis, namely, a closed ring of woody vessels, we can hardly avoid asking whether the difference between foliar and axial organs can be of so fundamental a nature as is generally supposed to be the case.

We have attempted to trace some of the stages in the genesis of climbing plants. But, during the endless fluctuations in the conditions of life to which all organic beings have been exposed, it might have been expected that some climbing plants would have lost the habit of climbing. In the cases of certain South African plants belonging to great twining families, which in certain districts of their native country never twine, but resume this habit when cultivated in England, we have a case in point. In the leaf-climbing *Clematis flammula*, and in the tendril-bearing vine, we see no loss in the power of climbing, but only a remnant of that revolving power which is indispensable to all twiners, and is so common, as well as so advantageous, to most climbers. In *Tecoma radicans*, one of the *Bignoniaceæ*, we see a last and doubtful trace of the revolving power.

With respect to the abortion of tendrils, certain cultivated varieties of *Cucurbita pepo* have, according to Naudin, either quite lost these organs or bear semi-monstrous representatives of them. In my limited experience I have met with only one instance of their natural suppression, namely, in the common bean. All the other species of *Vicia*, I believe, bear tendrils; but the bean is stiff enough to support its own stem, and in this species, at the end of the petiole where a tendril ought to have arisen, a small pointed filament is always present, about a third of an inch in length, and which must be considered as the rudiment of a tendril. This may be the more safely inferred, because I have seen in young, unhealthy

specimens of true tendril-bearing plants similar rudiments. In the bean these filaments are variable in shape, as is so frequently the case with all rudimentary organs, being either cylindrical or foliaceous, or deeply furrowed on the upper surface. It is a rather curious little fact that many of these filaments when foliaceous have dark-colored glands on their lower surfaces, like those on the stipules, which secrete a sweet fluid; so that these rudiments have been feebly utilized.

One other analogous case, though hypothetical, is worth giving. Nearly all the species of *Lathyrus* possess tendrils; but *L. nissolia* is destitute of them. This plant has leaves which must have struck every one who has noticed them with surprise, for they are quite unlike those of all common papilionaceous plants, and resemble those of a grass. In *L. aphaca* the tendril, which is not highly developed (for it is unbranched, and has no spontaneous revolving power), replaces the leaves, the latter in function being replaced by the large stipules. Now, if we suppose the tendrils of *L. aphaca* to become flattened and foliaceous, like the little rudimentary tendrils of the bean, and the large stipules, not being any longer wanted, to become at the same time reduced in size, we should have the exact counterpart of *L. nissolia*, and its curious leaves are at once rendered intelligible to us.

It may be added, as it will serve to sum up the foregoing views on the origin of tendril-bearing plants, that if these views be correct, *L. nissolia* must be descended from a primordial spirally twining

plant; that this became a leaf-climber; that first part of the leaf and then the whole leaf became converted into a tendril, with the stipules by compensation greatly increased in size; that this tendril lost its branches and became simple, then lost its revolving power (in which state it would resemble the tendril of the existing *L. aphaca*), and afterward losing its prehensile power and becoming foliaceous would no longer be called a tendril. In this last stage (that of the existing *L. nissolia*) the former tendril would reassume its original function as a leaf, and its lately largely developed stipules, being no longer wanted, would decrease in size. If it be true that species become modified in the course of ages, we may conclude that *L. nissolia* is the result of a long series of changes, in some degree like those just traced.

The most interesting point in the natural history of climbing plants is their diverse power of movement; and this led one on to their study. The most different organs—the stem, flower-peduncle, petiole, midribs of the leaf or leaflets, and apparently aerial roots—all possess this power.

In the first place, the tendrils place themselves in the proper position for action, standing, for instance, in the *Cobæa*, vertically upward, with their branches divergent and their hooks turned outward, and with the young terminal shoot thrown on one side; or, as in *Clematis*, the young leaves temporarily curve themselves downward, so as to serve as grapnels.

Secondly, if the young shoot of a twining plant,

or of a tendril, be placed in an inclined position, it soon bends upward, though completely secluded from the light. The guiding stimulus to this movement is no doubt the attraction of gravity, as Andrew Knight showed to be the case with germinating plants. If a succulent shoot of almost any plant be placed in an inclined position in a glass of water in the dark, the extremity will, in a few hours, bend upward; and if the position of the shoot be then reversed, the now downward bent shoot will reverse its curvature; but if the stolon of a strawberry, which has no tendency to grow upward, be thus treated, it will curve downward in the direction of, instead of in opposition to, the force of gravity. As with the strawberry, so it is generally with the twining shoots of the *Hibbertia dentata*, which climbs laterally from bush to bush; for these shoots, when bent downward, show little and sometimes no tendency to curve upward.

Thirdly, climbing plants, like other plants, bend toward the light by a movement closely analogous to that incurvation which causes them to revolve. This similarity in the nature of the movement was well seen when plants were kept in a room, and their first movements in the morning toward the light and their subsequent revolving movements were traced on a bell glass. The movement of a revolving shoot, and in some cases of a tendril, is retarded or accelerated in traveling from or to the light. In a few instances tendrils bend in a conspicuous manner toward the dark. Many authors speak as if the movement of a plant toward the light was as directly the

result of the evaporation or of the oxygenation of the sap in the stem, as the elongation of a bar of iron from an increase in its temperature. But, seeing that tendrils are either attracted to or repelled by the light, it is more probable that their movements are only guided and stimulated by its action in the same manner as they are guided by the force of attraction toward the centre of gravity.

Fourthly, we have in stems, petioles, flower-peduncles and tendrils the spontaneous revolving movement which depends on no outward stimulus, but is contingent on the youth of the part and on its vigorous health, which again, of course, depends on proper temperature and the other conditions of life. This is, perhaps, the most interesting of all the movements of climbing plants because it is continuous. Very many other plants exhibit spontaneous movements, but they generally occur only once during the life of a plant, as in the movements of the stamens and pistils, etc., or at intervals of time, as in the so-called sleep of plants.

Fifthly, we have in the tendrils, whatever their homological nature may be, in the petioles and tips of the leaves of leaf-climbers, in the stem in one case and apparently in the aerial roots of the vanilla, movements—often rapid movements—from contact with any body. Extremely slight pressure suffices to cause the movement. These several organs, after bending from a touch, become straight again, and again bend when touched.

Sixthly, and lastly, most tendrils, soon after clasping a support, but not after a mere temporary curva-

ture, contract spirally. The stimulus from the act of clasping some object seems to travel slowly down the whole length of the tendril. Many tendrils, moreover, ultimately contract spontaneously even if they have caught no object; but this latter useless movement occurs only after a considerable lapse of time.

We have seen how diversified are the movements of climbing plants. These plants are numerous enough to form a conspicuous feature in the vegetable kingdom; every one has heard that this is the case in tropical forests; but even in the thickets of our temperate regions the number of kinds and of individual plants is considerable, as will be found by counting them. They belong to many and widely different orders. To gain some crude idea of their distribution in the vegetable series, I marked from the lists given by Mohl and Palm (adding a few myself, and a competent botanist, no doubt, could add many more) all those families in *Lindley's Vegetable Kingdom*, which include plants in any of our several subdivisions of twiners, leaf-climbers, and tendril-bearers; and these (at least some of each group) all have the power of spontaneously revolving. Lindley divides Phanerogamic plants into fifty-nine alliances; of these, no less than above half, namely, thirty-five, include climbing plants according to the above definition, hook and root-climbers being excluded. To these a few Cryptogamic plants must be added which climb by revolving. When we reflect on this wide serial distribution of plants having this power, and when we know that in some

of the largest, well-defined orders, such as the Compositæ, Rubiaceæ, Scrophulariaceæ, Liliaceæ, etc., two or three genera alone, out of the host of genera in each, have this power, the conclusion is forced on our minds that the capacity of acquiring the revolving power on which most climbers depend is inherent though undeveloped in most every plant in the vegetable kingdom.

FLOWER COLORATION

—ALEXANDER S. WILSON

THE Prophet-plant (*Arnebia echioides*) is a native of Persia and Arabia, but has been introduced and grows freely in gardens in England. Its chief interest lies in its variable flowers, which may fairly rank with those of the changeable *Hibiscus* and other

“Plants divine and strange
That every hour their blossoms change.”

The plant is about two feet in height, and somewhat resembles a cowslip or an auricula. It belongs to the natural order Boraginaceæ, and is nearly allied to the lungwort, viper's-bugloss, borage, and forget-me-not, all of which exhibit color changes more or less distinct. The various species of *Myosotis*, or forget-me-not, are also called scorpion grasses, from the upper flower-bearing portion of the stem being curled on itself like a watch-spring. The cluster of flowers, forming the inflorescence of *Arnebia*, develops in same scorpioid fashion. There is a double

row of flower buds on the curled stalk, and as this gradually unwinds pair after pair of the flowers expand in succession. In shape and color the individual flowers are not unlike those of the primrose, though rather smaller. When a flower first opens, five conspicuous jet black spots are seen upon the yellow rim of the salver-shaped corolla. If the flower be examined the following day, we are surprised to discover that the black spots have vanished as if by magic. The yellow of the corolla is also much paler, and a little later on presents quite a bleached and silvery appearance, the petals becoming almost white. No sooner have the spots disappeared from the first pair of flowers than a second pair expand, and display their sable marks in bold relief upon the yellow enamel of their petals. From this time onward the inflorescence comprises both kinds of flower, those but newly opened having the five conspicuous spots, and the older ones on which no spots are visible. From these dark spots—the so-called finger-marks of Mahomet, *Arnebia* has received its name—the Prophet-plant. Its flowers seem bewitched, the change is so pronounced and obvious; a day or two after unfolding they differ so much from the newly opened ones beside them, that were they growing on separate plants, we should at once set them down as belonging to another species.

This change of color gives rise to another interesting peculiarity. If *Arnebia* be examined by daylight, and again in the dim twilight, the observer is struck by a remarkable circumstance. In broad daylight, the golden spotted flowers at once arrest the

eye, while their paler companions are hardly observed. The inflorescence owes by far the greater part of its display to the younger flowers. In the dusk this is entirely reversed; the conspicuousness of the inflorescence now depends on the paler flowers, and the others are so obscured that a second glance is needed before they can be discerned. The relative brilliancy of the two sets of flowers can also be tested by gradually retiring from the plant, keeping the eyes still fixed on the blossoms. At dusk the young flowers are lost sight of much sooner than the others; by day the older ones first disappear in the distance. This peculiar transformation imparts to the inflorescence of *Arnebia* a faint similitude of the pillar of cloud by day and of fire by night—that celestial manifestation of sacred story so closely associated with the native region of this desert flower.

Here, then, we have one of those phenomena which for the naturalist possess all the fascination of a mystery. What can be the explanation of this remarkable change of color, and what advantage does the flower derive from the sudden disappearance of its spots and the blanching of its petals?

With the reader's permission, we shall now proceed to show why nature has bestowed on *Arnebia* what she has denied to the leopard—the power of changing its spots. Before we can say why any flower should change its color, we must first know why a flower is colored at all, and why all flowers are not colored alike. Almost all the peculiarities of flowers can be explained as having reference to the visits of insects. The honey is secreted as an induce-

ment, while the secret and brilliant colors serve to attract the attention of the honey-gatherers. The researches of the late Charles Darwin demonstrated the importance of cross-fertilization in the vegetable kingdom. Very many flowers are quite sterile with their own pollen; in other cases, although the flower has the capacity of self-fertilization, the resulting seeds are of very inferior quality compared with those obtained as a result of cross-fertilization. As carriers of pollen, then, insects perform an essential service to plants, and it is in order to secure their services that flowers are brightly colored.

For the variety of color observed among flowers there appear to be two principal reasons. A little reflection will show that, since flowers are so dependent on insects for the conveyance of their pollen, it must be to the advantage of each species of plant to possess flowers distinctively colored and capable of being easily recognized by honey-seeking insects. A bee does not visit all flowers indiscriminately; it would be greatly to the flowers' disadvantage if it did. In the course of a single journey the bee for the most part restricts itself to the flowers of one species, and has been known to visit as many as thirty dead-nettles in succession, passing over all other flowers. Time is saved by this method, for by keeping to one kind of flower at a time the insect becomes familiar with its outs and ins, and the practice thus acquired enables it to overtake a larger number of blossoms than it could if it did not observe this rule. This constancy in visiting the same kind of flower is of great importance to plants, since it ensures that the

pollen will be conveyed to a flower of the same species as that from which it came. But if all flowers were colored and perfumed alike, the winged botanist could not identify the species; the pollen would be constantly transferred to the stigmas of the wrong flowers, where it would be useless, and so the work of cross-fertilization would be seriously impeded.

A second cause contributing to the variety observed among flowers is the desirability of attracting special kinds of insects. As we have just seen, an insect does not visit all kinds of flowers indiscriminately; neither, on the other hand, does a flower attract indiscriminately all kinds of insects. Not only are injurious and unprofitable visitors excluded, but the more specialized insects are in greatest demand. Partiality for particular insects is shown both by the shapes and coloring of flowers. Open shallow flowers, with exposed honey accessible to almost all insects, have, as their most frequent visitors, short-lipped flies and beetles. Many blossoms, again, have become specially adapted to bees. Their honey is placed beyond the reach of short-lipped fliers, and requires the slender proboscis of a bee or butterfly for its extraction. Honeysuckle, habernaria, plumbago, phlox, and narcissus illustrate a third type, with flower-tubes so narrow and deep that their nectar is quite inaccessible even to bees, and is reserved entirely for moths and butterflies, which possess an extremely long and thin proboscis. There is a corresponding adaptation in the colors; the gay tints of the buttercup, poppy, and rose appear to have special attractions for beetles; bees show a decided preference for

blue, and this color predominates in flowers whose shapes are adapted to their visits. Deep tubular flowers specialized for Lepidoptera fall into two divisions, according as they solicit the attentions of diurnal butterflies or nocturnal moths. Red and purple are the favorite colors of the former, while nocturnal moths show a preference for white and pale flowers. Thus the carnation and campion (*Lychnis diurna*), which open by day, have dark tints in comparison with *Lychnis respertina*, which unfolds its petals toward evening. Almost scentless by day, this white nocturnal flower diffuses a delicious fragrance in the twilight. The evening primrose (*Ænothera*), which, however, has yellow petals, is another example of this class. But the most remarkable plant of this type is the night-flowering stock (*Cereus*). Its pale blossoms open about seven in the evening, emit puffs of odor from time to time, and close up again toward midnight; by morning the flowers are withered. It is impossible to doubt that we have in this instance a flower specialized for the visits of nocturnal moths. The reason why nocturnal flowers, like the honeysuckle and evening campion, have pale-colored petals is not far to seek. These pale hues can be more easily distinguished at night than the red or purple of *Dianthus* or *Githago*. Among lilies both diurnal and nocturnal flowers occur, and clearly indicate by their colors to which section of the Lepidoptera they are adapted. The Turk's-cap lily, with its perianth of fiery scarlet, is a characteristic example of a diurnal flower adapted to butterflies which wander abroad in day-

time. On the other hand, *Lilium Martagon*, an *L. candidum*, with their white bells, are nocturnal lilies fertilized by night-loving moths.

Two flowers, unlike in their coloring, can hardly be equally attractive to the same visitors, even if they grow together on the same plant, as in the case of *Arnebia*; the presumption, therefore, is that its spotted and pale blossoms are adapted for different insects. Moreover, the stronger colors of the younger flowers correspond with those of the day-blooming class, while the paler tints of those in the second stage will render them more attractive to nocturnal moths; and this view is strongly confirmed by the fact that night-blooming flowers are never variegated, but have their petals uniformly devoid of markings. By night the dark spots tend, in this instance, to conceal the blossoms so much that, if these are to be converted into nocturnal flowers, the removal of the spots is absolutely necessary. We may therefore conclude with tolerable certainty that the flowers of *Arnebia* in their first stage are adapted to bees and diurnal Lepidoptera, while in their second condition they array themselves in paler hues to attract nocturnal moths.

By the color change, in this instance, a diurnal is converted into a nocturnal flower, and one advantage thereby gained is that the blossoms appeal to a larger class of fertilizing agents. The more restricted the circle of visitors on which any plant depends the greater the risk, in the event of insects being scarce, of its flowers remaining unfertilized and perishing. Here it would seem that Nature proceeds on the same

principle as a fisherman in changing his bait. Like some other variable blossoms, *Arnebia* is in the advantageous position of carrying two strings to her bow.

QUEER FLOWERS.—GRANT ALLEN

IF Baron Munchausen had ever in the course of his travels come across a single flower one standard British yard in diameter, fifteen pounds avoirdupois in weight, and forming a cup big enough to hold six quarts of water in its central hollow, it is not improbable that the learned baron's veracious account of the new plant might have been met with the same polite incredulity which his other adventures shared with those of Bruce, Stanley, Mendez Pinto, and Du Chaillu. Nevertheless, a big blossom of this enormous size has been well known to botanists ever since the beginning of the Nineteenth Century. When Sir Stamford Raffles was taking care of Sumatra during our temporary annexation, he happened one day to light upon a gigantic parasite, which grew on the stem of a prostrate creeper in the densest part of the tropical jungle. It measured nine feet round and three feet across: it had five large petals with a central basin; and it was mottled red in hue, being, in fact, in color and texture surprisingly suggestive of raw beefsteak. One flower was open when Sir Stamford came upon it: the other was in the bud, and looked in that state extremely like a very big red cabbage. Specimens of this surprising find were at once forwarded to England, and it was

at last duly labeled after the names of its two discoverers as *Rafflesia Arnoldi*.

The mere size of this mammoth among flowers would in itself naturally suffice to give it a distinct claim to respectful attention; but *Rafflesia* possesses many other sterling qualities far more calculated than simple bigness to endear it to a large and varied circle of insect acquaintances. The oddest thing about it, indeed, is the fact that it is a deliberately deceptive and alluring blossom. As soon as it was first discovered, Dr. Arnold noticed that it possessed a very curious carrion smell, exactly like that of putrefying meat. He also observed that this smell attracted flies in large numbers by false pretences to settle in the centre of the cup. But it is only of late years that the real significance and connection of these curious facts has come to be perceived. We now know that *Rafflesia* is a flower which wickedly and feloniously lays itself out to deceive the confiding meat-flies and to starve their helpless infants in the midst of apparent plenty. The majority of legitimate flowers (if I may be allowed the expression) get themselves decently fertilized by bees and butterflies, who may be considered as representing the regular trade, and who carry the fecundating pollen on their heads and proboscises from one blossom to another, while engaged in their usual business of gathering honey every day from every opening flower. But *Rafflesia*, on the contrary, has positively acquired a fallacious external resemblance to raw meat, and a decidedly high flavor, on purpose to take in the too trustful Sumatran flies. When a fly sights

and scents one, he (or rather she) proceeds at once to settle in the cup, and there lay a number of eggs in what it naturally regards as a very fine decaying carcass. Then, having dusted itself over in the process with plenty of pollen from this first flower, it flies away confidently to the next promising bud, in search both of food for itself and of a fitting nursery for its future little ones. In doing so, it of course fertilizes all the blossoms that it visits, one after another, by dusting them successively with each other's pollen. When the young grubs are hatched out, however, they discover the base deception all too late, and perish miserably in their fallacious bed, the hapless victims of misplaced parental confidence. Even as Zeuxis deceived the very birds with his painted grapes, so *Rafflesia* deceives the flies themselves by its ingenious mimicry of a putrid beefsteak. In the fierce competition of tropical life, it has found out by simple experience that dishonesty is the best policy.

The general principle which this strange flower illustrates in so striking a fashion is just this. Most common flowers have laid themselves out to attract bees, and so a bee flower forms our human ideal of central typical blossom: it looks, in short, we think, as a flower ought to look. But there are some originally minded and eccentric plants which have struck out a line for themselves, and taken to attracting sundry casual flies, wasps, midges, beetles, snails, or even birds, which take the place of bees as their regular fertilizers; and it is these Bohemians of the vegetable world that make up what we all consider as the

queerest and most singular of all flowers. They adapt their appearance and structure to the particular tastes and habits of their chosen guests.

Most of the flowers specially affected by carrion flies have a lurid red color and a distinct smell of bad meat. Few of them, however, are quite so cruel in their habits as *Rafflesia*. For the most part, they attract the insects by their appearance and odor, but reward their services with a little honey and other allurements. This is the case with the curious English fly-orchid, whose dull purple lip is covered with tiny drops of nectar, licked off by the fertilizing flies. The very malodorous carrion-flowers (or stapelias) are visited by blue-bottles and flesh-flies, while an allied form actually sets a trap for the fly's proboscis, which catches the insect by its hairs, and compels him to give a sharp pull in order to free himself: this pull dislodges the pollen, and so secures cross-fertilization. The Alpine butterwort sets a somewhat similar gin so vigorously that when a weak fly is caught in it he can not disengage himself, and there perishes wretchedly, like a hawk in a keeper's trap.

The south European birthwort, a very lurid-looking and fly-enticing flower, has a sort of cornucopia-shaped tube, lined with long hairs, which all point inward, and so allow small midges to creep down readily enough, after the fashion of an eel-buck or lobster-pot. "*Sed revocare gradum, superasque evadere ad auras*"—to get out again is the great difficulty. Try as they will, the little prisoners can not crawl back upward against the downward-point-

ing hairs. Accordingly, they are forced by circumstances over which they have no control to walk aimlessly up and down their prison yard, fertilizing the little knobby surface of the seed-vessel from another flower. But as soon as the seeds are all impregnated, the stamens begin to shed their pollen, and dust over the gnats with copious powder. Then the hairs all wither up, and the gnats, released from their lobster-pot prison, fly away once more on the same fool's errand. Before doing so, however, they make a good meal off the pollen that covers the floor, though they still carry away a great many grains on their own wings and bodies.

A very similar but much larger fly-cage is set by our common wild arum, or cuckoo-pint. This familiar big spring flower exhales a disagreeable fleshy odor, which, by its meat-like flavor, attracts a tiny midge with beautiful iridescent wings and a very poetical name, *Psychoda*. As in most other cases where flies are specially invited, the color of the cuckoo-pint is usually a dull and somewhat livid purple. A palisade of hairs closes the neck of the funnel-shaped blossom, and repeats the lobster-pot tactics of the entirely unconnected south European birthwort. The little flies, entering by this narrow and stockaded door, fertilize the future red berries with pollen brought from their last prison, and are then rewarded for their pains by a tiny drop of honey, which slowly oozes from the middle of each embryo fruitlet as soon as it is duly impregnated. Afterward, the pollen is shed upon their backs by the bursting of the pollen-bag; the hairs wither up, and

open the previously barricaded exit, and the midges issue forth in search of a new prison and a second drop of honey.

From plants that imprison insects to plants that devour insects alive is a natural transition. The giant who keeps a dungeon is first cousin to the ogre who swallows down his captives entire. And yet the subject is really too serious a one for jesting; there is something too awful and appalling in this contest of the unconscious and insentient with the living and feeling, of a lower vegetative form of life with a higher animated form, that it always makes me shudder slightly to think of it.

On most English peaty patches there grows a little reddish-leaved odd-looking plant known as sundew. It is but an inconspicuous small weed, and yet literary and scientific honors have been heaped upon its head to an extent almost unknown in the case of any other member of the British floral commonwealth. Mr. Swinburne has addressed an ode to it, and Mr. Darwin has written a learned book about it. Its portrait has been sketched by innumerable artists, and its biography narrated by innumerable authors. And all this attention has been showered upon it, not because it is beautiful, or good, or modest, or retiring, but simply and solely because it is atrociously and deliberately wicked. Sundew, in fact, is the best known and most easily accessible of the carnivorous and insectivorous plants.

The leaf of the sundew is round and flat, and it is covered by a number of small red glands, which act as the attractive advertisement to the misguided

midges. Their knobby ends are covered with a glutinous secretion, which glistens like honey in the sunlight, and so gains for the plant its common English name. But the moment a hapless fly, attracted by hopes of meat or nectar, settles quietly in its midst, on hospitable thoughts intent, the viscid liquid holds him tight immediately, and clogs his legs and wings, so that he is snared exactly as a peregrine is snared with bird-lime. Then the leaf, with all its "red-lipped mouths," closes over him slowly but surely, and crushes him by folding its edges inward gradually toward the centre. The fly often lingers long with ineffectual struggles, while the cruel crawling leaf pours forth a digestive fluid—a vegetable gastric juice, as it were—and dissolves him alive piecemeal in its hundred clutching suckers.

Our little English insectivorous plants, however (we have at least five or six such species in our own islands), are mere clumsy bunglers compared to the great and highly developed insect-eaters of the tropics, which stand to them in somewhat the same relation as the Bengal tiger stands to the British wild-cat or the skulking weasel. The Indian pitcher-plants or *Nepenthes* bear big pitchers of very classical shapes, closed in the early state with a lid, which lifts itself and opens the pitcher as soon as the plant has fully completed its insecticidal arrangements. The details of the trap vary somewhat in the different species, but as a whole the *modus operandi* of the plant is somewhat after this atrocious fashion. The pitcher contains a quantity of liquid, that of the sort appropriately known as the Rajah holding as much as a

quart; and the insect, attracted in most cases by some bright color, crawls down the sticky side, quaffs the unkind Nepenthe, and forgets his troubles forthwith in the vat of oblivion prepared for him beneath by the delusive vase. A slimy Lethe flows over his dissolving corse, and the relentless pitcher-plant sucks his juices to supply his own fibres with the necessary nitrogenous materials.

The California pitcher-plant, or *Darlingtonia*, is a member of a totally distinct family, which has independently hit upon the same device in the Western world as the Indian *Nepenthes* in the Eastern Hemisphere. The pitcher in this case, though differently produced, is hooded and lidded like its Oriental analogue; but the inside of the hood is furnished with short hairs, all pointing inward, and legibly inscribed (to the botanical eye) with the appropriate motto: "*Vestigia nulla retrorsum*." The whole arrangement is colored dingy orange, so as to attract the attention of flies; and it contains a viscid digestive fluid in which the flies are first drowned and then slowly melted and assimilated. The pitchers are often found half full of dead and decaying assorted insects.

There are a great many more of these highly developed insect-eaters, such as the Guiana *heliamphora* (more classical shapes), the Australian *cephalotus*, and the American side-saddle flowers, and they all without exception grow in very wet and boggy places, like the English sundews, butterworts, and bladderworts. The reason so many marsh plants have taken to these strange insect-eating habits is simply that their roots are often badly supplied with

manure or ammonia in any form; and, as no plant can get on without these necessities of life (in the strictest sense), only those marshy weeds have any chance of surviving which can make up in one way or another for the native deficiencies of their situation. The sundews show us, as it were, the first stage in the acquisition of these murderous habits; the pitcher-plants are the abandoned ruffians which have survived among all their competitors in virtue of their exceptional ruthlessness and deceptive coloration. I ought to add that in all cases the pitchers are not flowers, but highly modified and altered leaves, though in many instances they are quite as beautifully colored as the largest and handsomest exotic orchids.

The principle of Venus's Fly-trap is somewhat different, though its practice is equally nefarious. This curious marsh-plant, instead of setting hocussed bowls of liquid for its victims, like a Florentine of the Fourteenth Century, lays a regular gin or snare for them on the same plan as a common snapping rat-trap. The end of the leaf is divided into two folding halves by the midrib, and on each half are three or five highly sensitive hairs. The moment one of these hairs is touched by a fly, the two halves come together, inclosing the luckless insect between them. As if on purpose to complete the resemblance to a rat-trap, too, the edges of the leaf are formed of prickly jagged teeth, which fit in between one another when the gin shuts, and so effectually cut off the insect's retreat. The plant then sucks up the juices of the fly; and as soon as it has fully digested them, the

leaf opens automatically once more, and resets the trap for another victim. It is an interesting fact that this remarkable insectivore appears to be still a new and struggling species, or else an old type on the very point of extinction, for it is only found in a few bogs over a very small area in the neighborhood of Wilmington, South California.

ATHENA IN THE EARTH

—JOHN RUSKIN

THE spirit in the plant—that is to say, its power of gathering dead matter out of the wreck round it, and shaping it into its own chosen shape—is, of course, strongest at the moment of its flowering, for it then not only gathers, but forms, with the greatest energy.

And where this life is in it at full power, its form becomes invested with aspects that are chiefly delightful to our own human passions; namely, first, with the loveliest outlines of shape; and, secondly, with the most brilliant phases of the primary colors, blue, yellow, and red or white, the unison of all; and, to make it all more strange, this time of peculiar and perfect glory is associated with relations of the plants or blossoms to each other, correspondent to the joy of love in human creatures, and having the same object in the continuance of the race. Only, with respect to plants, as animals, we are wrong in speaking as if the object of this strong life were only the bequeathing of itself. The flower is the end or proper object of the seed, not the seed of the

flower. The reason for seeds is that flowers may be; not the reason of flowers that seeds may be. The flower itself is the creature which the spirit makes; only, in connection with its perfectness, is placed the giving birth to its successor.

The main fact, then, about a flower is that it is the part of the plant's form developed at the moment of its intensest life: and this inner rapture is usually marked externally for us by the flush of one or more of the primary colors. What the character of the flower shall be depends entirely upon the portion of the plant into which this rapture of spirit has been put. Sometimes the life is put into its outer sheath, and then the outer sheath becomes white and pure, and full of strength and grace; sometimes the life is put into the common leaves, just under the blossom, and they become scarlet or purple; sometimes the life is put into the stalks of the flower, and they flush blue; sometimes in its outer inclosure or calyx; mostly into its inner cup; but, in all cases, the presence of the strongest life is asserted by characters in which the human sight takes pleasure, and which seemed prepared with distinct reference to us, or rather, bear, in being delightful, evidence of having been produced by the power of the same spirit as our own.

With the early serpent-worship there was associated another—that of the groves—of which you will find the evidence exhaustively collected in Mr. Fergusson's work. This tree-worship may have taken a dark form when associated with the Draconian one; or opposed, as in Judea, to a purer faith;

but in itself, I believe, it was always healthy, and though it retains little definite hieroglyphic power in subsequent religion, it becomes, instead of symbolic, real; the flowers and trees are themselves beheld and beloved with a half-worshiping delight, which is always noble and healthful.

And it is among the most notable indications of the volition of the animating power that we find the ethical signs of good and evil set on these also, as well as upon animals; the venom of the serpent, and in some respects its image also, being associated even with the passionless growth of the leaf out of the ground; while the distinctions of species seem appointed with more definite ethical address to the intelligence of man as their material products become more useful to him.

I can easily show this and, at the same time, make clear the relation to other plants of the flowers which especially belong to Athena, by examining the natural myths in the groups of the plants which would be used at any country dinner over which Athena would, in her simplest household authority, cheerfully rule, here, in England. Suppose Horace's favorite dish of beans with the bacon; potatoes; some savory stuffing of onions and herbs with the meat; celery, and a radish or two, with the cheese; nuts and apples for dessert, and brown bread. The beans are, from earliest time, the most important and interesting of the seeds of the great tribe of plants from which came the Latin and French name for all kitchen vegetables—things that are gathered with the hand—podded seeds that can not be reaped,

or beaten, or shaken down, but must be gathered green. "Leguminous" plants, all of them having flowers like butterflies, seeds in (frequently pendent) pods—"lætum silique quassante legumen"—smooth and tender leaves, divided into many minor ones—strange adjuncts of tendril, for climbing (and sometimes of thorn)—exquisitely sweet, yet pure, scents of blossom, and almost always harmless, if not serviceable seeds. It is of all tribes of plants the most definite; its blossoms being entirely limited in their parts, and not passing into other forms. It is also the most usefully extended in range and scale; familiar in the height of the forest—acacia, laburnum, Judas-tree; familiar in the sown field—bean and vetch and pea; familiar in the pasture—in every form of clustered clover and sweet trefoil tracery; the most entirely serviceable and human of all orders of plants.

Next, in the potato, we have the scarcely innocent underground stem of one of a tribe set aside for evil;* having the deadly nightshade for its queen, and including the henbane, the witch's mandrake, and the worst natural curse of modern civilization—tobacco. And the strange thing about this tribe is that, though thus set aside for evil, they are not a group distinctly separate from those that are happier in function. There is nothing in other tribes of plants like the bean blossom; but there is another family with forms and structure closely connected with this venomous one. Examine the purple and

* Some two out of one hundred and fifty species of *Solanum* are useful to man.

yellow bloom of the common hedge nightshade; you will find it constructed exactly like some of the forms of the cyclamen; and, getting this clew, you will find at last the whole poisonous and terrible group to be—sisters of the primulas!

The nightshades are, in fact, primroses with a curse upon them; and a sign set in their petals by which the deadly and condemned flowers may always be known from the innocent ones—that the stamens of the nightshades are between the lobes, and of the primulas, opposite the lobes of the corolla.

Next, side by side, in the celery and radish, you have the two great groups of umbelled and cruciferous plants; alike in conditions of rank among herbs: both flowering in clusters; but the umbelled group, flat, the crucifers, in spires: both of them mean and poor in blossom, and losing what beauty they have by too close crowding; both of them having the most curious influence on human character in the temperate zones of the earth, from the days of the parsley crown and hemlock drink, and mocked Euripidean chervil, until now: but chiefly among the northern nations, being especially plants that are of some humble beauty, and (the crucifers) of endless use, when they are chosen and cultivated; but that run to wild waste, and are signs of neglected ground, in their rank or ragged leaves, and meagre stalks, and pursed or podded seed-clusters. Capable, even under cultivation, of no perfect beauty, though reaching some subdued delightfulness in the lady's smock and the wall-flower; for the most part, they

have every floral quality meanly, and in vain—they are white, without purity; golden, without preciousness; redundant, without richness; divided, without fineness; massive, without strength; and slender, without grace. Yet think over that useful vulgarity of theirs; and of the relations of German and English peasant character to its food of kraut and cabbage (as of Arab character to its food of palm-fruit), and you will begin to feel what purposes of the forming spirit are in these distinctions of species.

Next we take the nuts and apples—the nuts representing one of the groups of catkined trees whose blossoms are only tufts and dust; and the other, the rose tribe, in which fruit and flower alike have been the types, to the highest races of men, of all passionate temptation or pure delight, from the coveting of Eve to the crowning of the Madonna above the

“*Rosa sempiterna*
Che si dilata, rigrada, e ridole
Odor di lode al Sol.”

We have now no time for these; we must go on to the humblest group of all, yet the most wonderful, that of the grass, which has given us our bread; and from that we will go back to the herbs.

The vast family of plants which, under rain, make the earth green for man; and, under sunshine, give him bread; and, in their springing in the early year, mixed with their native flowers, have given us (far more than the new leaves of trees) the thought and word of “spring,” divide themselves broadly into three great groups—the grasses, sedges, and rushes.

The grasses are essentially a clothing for healthy and pure ground, watered by occasional rain, but in itself dry and fit for all cultivated pasture and corn. They are distinctively plants with round and pointed stems, which have long, green, flexible leaves, and heads of seed independently emerging from them. The sedges are essentially the clothing of waste and more or less poor or uncultivable soils, coarse in their structure, frequently triangular in stem—hence called “acute” by Virgil—and with their heads of seed not extricated from their leaves. Now, in both the sedges and grasses, the blossom has a common structure, though undeveloped in the sedges, but composed always of groups of double husks, which have mostly a spinous process in the centre, sometimes projecting into a long awn or beard; this central process being characteristic also of the ordinary leaves of mosses, as if a moss were a kind of ear of corn made permanently green on the ground, and with a new and distinct fructification. But the rushes differ wholly from the sedge and grass in their blossom structure. It is not a dual cluster, but a twice threefold one, so far separate from the grasses and so closely connected with a higher order of plants that I think you will find it convenient to group the rushes at once with that higher order, to which, if you will for the present let me give the general name of *Drosidæ*, or dew-plants, it will enable me to say what I have to say of them much more shortly and clearly.

These *Drosidæ*, then, are plants delighting in interrupted moisture—moisture which comes either

partially or at certain seasons—into dry ground. They are not water-plants; but the signs of water resting among dry places. Many of the true water-plants have triple blossoms, with a small triple calyx holding them; in the *Drosidæ*, the floral spirit passes into the calyx also, and the entire flower becomes a six-rayed star, bursting out of the stem laterally, as if it were the first of flowers, and had made its way to the light by force through the unwilling green. They are often required to retain moisture or nourishment for the future blossom through long times of drought; and this they do in bulbs under ground, of which some become a rude and simple, but most wholesome, food for man.

So now, observe, you are to divide the whole family of the herbs of the field into three great groups—*Drosidæ*, *Carices*, *Gramineæ*—dew-plants, sedges, and grasses. Then the *Drosidæ* are divided into five great orders—lilies, asphodels, amaryllids, irids, and rushes. No tribes of flowers have had so great, so varied, or so healthy an influence on man as this great group of *Drosidæ*, depending not so much on the whiteness of some of their blossoms, or the radiance of others, as on the strength and delicacy of the substance of their petals; enabling them to take forms of faultless elastic curvature, either in cups, as the crocus, or expanding bells, as the true lily, or heath-like bells, as the hyacinth, or bright and perfect stars, like the star of Bethlehem, or, when they are affected by the strange reflex of the serpent nature which forms the labiate group of all flowers, closing into forms of exquisitely fantastic symmetry in

the gladiolus. Put by their side their Nereid sisters, the water-lilies, and you have in them the origin of the loveliest forms of ornamental design and the most powerful floral myths yet recognized among human spirits, born by the streams of the Ganges, Nile, Arno, and Avon.

For consider a little what each of those five tribes has been to the spirit of man. First, in their nobleness: the lilies gave the lily of the Annunciation; the asphodels, the flower of the Elysian fields; the irids, the fleur-de-lys of chivalry; and the amaryllids, Christ's lily of the field; while the rush, trodden always underfoot, became the emblem of humility. Then take each of the tribes, and consider the extent of their lower influence. Perdita's, "The crown imperial, lilies of all kinds," are the first tribe; which giving the type of perfect purity in the Madonna's lily, have, by their lovely form, influenced the entire decorative design of Italian sacred art; while ornament of war was continually enriched by the curves of the triple petals of the Florentine "giglio" and French fleur-de-lys; so that it is impossible to count their influence for good in the Middle Ages, partly as a symbol of womanly character and partly of the utmost brightness and refinement of chivalry in the city which was the flower of cities.

Afterward the group of the turban-lilies, or tulips, did some mischief (their special stains having made them the favorite caprice of florists); but they may be pardoned all such guilt for the pleasure they have given in cottage-gardens, and are yet to give, when lowly life may again be possible among us; and

the crimson bars of the tulips in their trim beds, with their likeness in crimson bars of morning above them, and its dew glittering heavy, globed in their glossy cups, may be loved better than the gray nettles of the ash heap, under gray sky, unveined by vermilion or by gold.

The next great group of the asphodels divides itself also into two principal families: one, in which the flowers are like stars, and clustered characteristically in balls, though opening sometimes into looser heads; and the other, in which the flowers are in long bells, opening suddenly at the lips, and clustered in spires on a long stem, or drooping from it when bent by their weight.

The star group of the squills, garlics, and onions has always caused me great wonder. I can not understand why its beauty and serviceableness should have been associated with the rank scent which has been really among the most powerful means of degrading peasant life, and separating it from that of the higher classes.

The belled group of the hyacinth and convallaria is as delicate as the other is coarse; the unspeakable azure light along the ground of the wood hyacinth in English spring; the grape hyacinth, which is in south France, as if a cluster of grapes and a hive of honey had been distilled and compressed together into one small boss of celled and beaded blue; the lilies of the valley everywhere, in each sweet and wild recess of rocky land—count the influences of these on childish and innocent life; then measure the mythic power of the hyacinth and

asphodel as connected with Greek thoughts of immortality; finally take their useful and nourishing power in ancient and modern peasant life, and it will be strange if you do not feel what fixed relation exists between the agency of the creating spirit in these and in us who live by them.

It is impossible to bring into any tenable compass for our present purpose even hints of the human influence of the amaryllids and irids—only note this generally, that while these in northern countries share with the *Primulas* the fields of spring, it seems that in Greece the *Primulaceæ* are not an extended tribe, while the crocus, narcissus, and *Amaryllis lutea*, the “lily of the field” (I suspect also that the flower whose name we translate “violet” was in truth an iris), represented to the Greek the first coming of the breath of life on the renewed herbage; and became in his thoughts the true embroidery of the saffron robe of Athena. Later in the year, the *dianthus* (which, though belonging to an entirely different race of plants, has yet a strange look of having been made out of the grasses by turning the sheath-membrane at the root of their leaves into a flower) seems to scatter, in multitudinous families, its crimson stars far and wide. But the golden lily and crocus, together with the asphodel, retain always the old Greek’s fondest thoughts—they are only “golden” flowers that are to burn on the trees and float on the streams of paradise.

I have but one tribe of plants more to note at our country feast—the savory herbs; but must go a little out of my way to come at them rightly. All

flowers whose petals are fastened together, and most of those whose petals are loose, are best thought of first as a kind of cup or tube opening at the mouth. Sometimes the opening is gradual, as in the convolvulus or campanula; oftener there is a distinct change of direction between the tube and expanding lip, as in the primrose; or even a contraction under the lip, making the tube into a narrow-necked phial or vase, as in the heaths, but the general idea of a tube expanding into a quatrefoil, cinquefoil, or sixfoil, will embrace most of the forms.

Now it is easy to conceive that flowers of this kind, growing in close clusters, may, in process of time, have extended their outside petals rather than the interior ones (as the outer flowers of the clusters of many umbellifers actually do), and thus elongated and variously distorted forms have established themselves; then if the stalk is attached to the side instead of the base of the tube, its base becomes a spur, and thus all the grotesque forms of the mints, violets, and larkspurs gradually might be composed. But, however this may be, there is one great tribe of plants separate from the rest, and of which the influence seems shed upon the rest in different degrees: and these would give the impression not so much of having been developed by change as of being stamped with a character of their own, more or less serpentine or dragon-like. And I think you will find it convenient to call these generally *Draconidæ*; disregarding their present ugly botanical name, which I do not care even to write once—you may take for their principal types

the foxglove, snap-dragon, and calceolaria; and you will find they all agree in a tendency to decorate themselves by spots, and with bosses or swollen places in their leaves, as if they had been touched by poison. The spot of the foxglove is especially strange, because it draws the color out of the tissue all round it, as if it had been stung, and as if the central color was really an inflamed spot with paleness round. Then also they carry to its extreme the decoration by bulging or pouting the petal; often beautifully used by other flowers in a minor degree, like the beating out of bosses in hollow silver, as in the kalmia, beating out apparently in each petal by the stamens instead of a hammer; or the borage, pouting inward; but the snap-dragons and calceolarias carry it to its extreme.

Then the spirit of these *Draconidæ* seems to pass more or less into other flowers, whose forms are properly pure vases; but it affects some of them slightly, others not at all. It never strongly affects the heaths; never once the roses; but it enters like an evil spirit into the buttercup, and turns it into a larkspur, with a black, spotted, grotesque centre, and a strange, broken blue, gorgeous and intense, yet impure, glittering on the surface as if it were strewn with broken glass, and stained or darkened irregularly into red. And then at last the serpent-charm changes the ranunculus into monkshood, and makes it poisonous. It enters into the forget-me-not, and the star of heavenly turquoise is corrupted into the viper's bugloss, darkened with the same strange red as the larkspur, and fretted into a fringe of thorn;

it enters, together with a strange insect-spirit, into the asphodels, and (though with a greater interval between the groups), they change into spotted orchideæ; it touches the poppy, it becomes a fumaria; the iris, and it pouts into a gladiolus; the lily, and it checkers itself into a snake's head, and secretes in the deep of its bell drops not of venom indeed, but honey-dew, as if it were a healing serpent. For there is an Æsculapian as well as an evil serpentry among the Draconidæ, and the fairest of them, "erba della Madonna" of Venice (*Linaria Cymbalaria*), descends from the ruins it delights in to the herbage at their feet, and touches it; and behold, instantly, a vast group of herbs for healing—all draconid in form—spotted and crested, and from their lip-like corollas named "labitæ"; full of various balm and warm strength for healing, yet all of them without splendid honor or perfect beauty, "ground ivies," richest when crushed under the foot; the best sweetness and gentle brightness of the robes of the field—thyme, and marjoram, and euphrasy.

And observe, again and again, with respect to all these divisions and powers of plants; it does not matter in the least by what concurrences of circumstance or necessity they may gradually have been developed: the concurrence of circumstance is itself the supreme and inexplicable fact. We always come at last to a formative cause which directs the circumstance and mode of meeting it. If you ask an ordinary botanist the reason of the form of a leaf, he will tell you it is a "developed tubercle," and that its ultimate form "is owing to the directions of its vascular threads."

But what directs its vascular threads? "They are seeking for something they want," he will probably answer. What made them want that? What made them seek for it thus? Seek for it, in five fibres or in three? Seek for it, in serration, or in sweeping curves? Seek for it, in servile tendrils, or impetuous spray? Seek for it, in woolen wrinkles rough with stings, or in glossy surfaces, green with pure strength, and winterless delight?

There is no answer. But the sum of all is, that over the entire surface of the earth and its waters, as influenced by the power of the air under solar light, there is developed a series of changing forms, in clouds, plants, and animals, all of which have reference in their action, or nature, to the human intelligence that perceives them; and on which, in their aspects of horror and beauty, and their qualities of good and evil, there is engraved a series of myths, or words of the forming power, which, according to the true passion and energy of the human race, they have been enabled to read into religion.

PROGRESS OF CULTIVATION

—ALPHONSE DE CANDOLLE

IN spite of the obscurity of the beginnings of cultivation in each region, it is certain that they occurred at very different periods. One of the most ancient examples of cultivated plants is in a drawing representing figs, found in Egypt in the pyramid of Gizeh. The epoch of the construction of this monument is uncertain. Authors have assigned a date

varying between fifteen hundred and four thousand two hundred years before the Christian era. Supposing it to be two thousand years, its actual age would be four thousand years. Now, the construction of the pyramids could only have been the work of a numerous, organized people, possessing a certain degree of civilization, and consequently an established agriculture, dating from some centuries back at least. In China, two thousand seven hundred years before Christ, the Emperor Chenming instituted the ceremony at which every year five species of useful plants are sown—rice, sweet potato, wheat, and two kinds of millet. These plants must have been cultivated for some time in certain localities before they attracted the emperor's attention to such a degree. Agriculture appears then to be as ancient in China as in Egypt. The constant relations between Egypt and Mesopotamia lead us to suppose that an almost contemporaneous cultivation existed in the valleys of the Euphrates and the Nile. And it may have been equally early in India and in the Malay Archipelago. The history of the Dravidian and Malay peoples does not reach far back, and is sufficiently obscure, but there is no reason to believe that cultivation has not been known among them for a very long time, particularly along the banks of the rivers.

The ancient Egyptians and the Phœnicians propagated many plants in the region of the Mediterranean, and the Aryan nations, whose migrations toward Europe began about 2500, or at least 2000 years B. C., carried with them several species already cultivated in Western Asia. We shall see, in studying the



Common Cereals and Food Plants

1, Lentil ; 2, Flax ; 3, Barley ; 4, Millet ; 5, Rye

history of several species, that some plants were probably cultivated in Europe and in the north of Africa prior to the Aryan migration. This is shown by names in languages more ancient than the Aryan tongues; for instance, Finn, Basque, Berber, and the speech of the Guanchos of the Canary Isles. However, the remains called kitchen-middens, of ancient Danish dwellings, have hitherto furnished no proof of cultivation or any indication of the possession of metal. The Scandinavians of that period lived principally by fishing and hunting, and perhaps eked out their subsistence by indigenous plants, such as the cabbage, the nature of which does not admit any remnant of traces in the dung-heaps and rubbish, and which, moreover, did not require cultivation. The absence of metals does not in these northern countries argue a greater antiquity than the age of Pericles, or even the palmy days of the Roman Republic. Later, when bronze was known in Sweden—a region far removed from the then civilized countries—agriculture had at length been introduced. Among the remains of that epoch was found a carving of a cart drawn by two oxen and driven by a man.

The ancient inhabitants of Eastern Switzerland, at a time when they possessed instruments of polished stone and no metals, cultivated several plants, of which some were of Asiatic origin. Heer has shown in his admirable work on the lake-dwellings that the inhabitants had intercourse with the countries south of the Alps. They may also have received plants cultivated by the Ibernians, who occupied Gaul before the Kelts. At the period when the lake-dwellers

of Switzerland and Savoy possessed bronze, their agriculture was more varied. It seems that the lake-dwellers of Italy, when in possession of this metal, cultivated fewer species than those of Savoy, and this may be due either to a greater antiquity, or to local circumstances. The remains of the lake-dwellers of Laybach and of the Mondsee in Austria prove likewise a completely primitive agriculture; no cereals have been found at Laybach, and but a single grain of wheat at the Mondsee. The backward condition of agriculture in this eastern part of Europe is contrary to the hypothesis, based on a few words used by ancient historians, that the Aryans sojourned first in the region of the Danube, and that Thrace was civilized before Greece. In spite of this example, agriculture seems in general to have been more ancient in the temperate parts of Europe than we should be inclined to believe from the Greeks, who were disposed, like certain modern writers, to attribute the origin of all progress to their own nation.

In America, agriculture is perhaps not quite so ancient as in Asia and Egypt, if we are to judge from the civilization of Mexico and Peru, which does not date even from the first centuries of the Christian era. However, the widespread cultivation of certain plants, such as maize, tobacco, and the sweet potato, argues a considerable antiquity, perhaps two thousand years or thereabout. History is at fault in this matter, and we can only hope to be enlightened by the discoveries of archæology and geology.

The greater number of ancient historians have confused the fact of a cultivation of a species in a country

with that of its previous existence there in a wild state. It has been commonly asserted, even in our own day, that a species cultivated in America or China is a native of America or China. A no less common error is the belief that a species comes originally from a given country because it has come to us from thence, and not direct from the place in which it is really indigenous. Thus the Greeks and Romans called the peach the Persian apple, because they had seen it cultivated in Persia, where it probably did not grow wild. It was a native of China. They called the pomegranate, which had spread gradually from garden to garden from Persia to Mauritania, the apple of Carthage (*Malum Punicum*). Very ancient authors, such as Herodotus and Berosus, are yet more liable to error, in spite of their desire to be accurate.

Agriculture came originally, at least so far as the principal species are concerned, from three great regions, in which certain plants grew, regions which had no communication with each other. These are: China, the southwest of Asia (with Egypt), and intertropical America. I do not mean to say that in Europe, in Africa, and elsewhere savage tribes may not have cultivated a few species locally, at an early epoch, as an addition to the resources of hunting and fishing; but the greater civilizations based upon agriculture began in the three regions I have indicated. It is worthy of note that in the Old World agricultural communities established themselves along the banks of the rivers, whereas in America they dwelt on the

highlands of Mexico and Peru. This may perhaps have been due to the original situation of the plants suitable for cultivation, for the banks of the Mississippi, of the Amazon, of the Orinoco, are not more unhealthy than those of the rivers of the Old World. A few words about each of the three regions. China had already possessed for some thousands of years a flourishing agriculture and even horticulture, when she entered for the first time into relations with Western Asia, by the mission of Chang-Kien, during the reign of the Emperor Wu-ti, in the second century before the Christian era. The records known as Pent-sao, written in our Middle Ages, state that he brought back the bean, the cucumber, the lucern, the saffron, the sesame, the walnut, the pea, the spinach, the watermelon, and other western plants, then unknown to the Chinese. Chang-Kien, it will be observed, was no ordinary ambassador. He considerably enlarged the geographical knowledge and improved the economic condition of his countrymen. It is true that he was constrained to dwell ten years in the west, and that he belonged to an already civilized people, one of whose emperors had, 2700 B. C., consecrated with imposing ceremonies the cultivation of certain plants. The Mongolians were too barbarous, and came from too cold a country, to have been able to introduce many useful species into China; but when we consider the origin of the peach and the apricot, we shall see that these plants were brought into China from Western Asia, probably by isolated travelers, merchants or others, who passed north of the Himalayas. A few species spread in the same way into

China from the west before the embassy of Chang-Kien.

Regular communication between China and India only began in the time of Chang-Kien, and by the circuitous way of Bactriana; but gradual transmissions from place to place may have been effected through the Malay Peninsula and Cochin-China. The writers of northern China may have been ignorant of them, and especially since the southern provinces were only united to the empire in the second century before Christ.

Regular communications between China and Japan only took place about the year 57 of our era, when an ambassador was sent; and the Chinese had no real knowledge of their eastern neighbors until the Third Century, when the Chinese character was introduced into Japan.

The vast region which stretches from the Ganges to Armenia and the Nile was not in ancient times so isolated as China. Its inhabitants exchanged cultivated plants with great facility, and even transported them to a distance. It is enough to remember that ancient migrations and conquests continually intermixed the Turanian, Aryan, and Semitic peoples between the great Caspian Sea, Mesopotamia and the Nile. Great states were formed nearly at the same time on the banks of the Euphrates and in Egypt, but they succeeded to tribes which had already cultivated certain plants. Agriculture is older in that region than Babylon and the first Egyptian dynasties, which date from more than four thousand years ago. The Assyrian and Egyp-

tian empires afterward fought for supremacy, and in their struggles they transported whole nations, which could not fail to spread cultivated species. On the other hand, the Aryan tribes who dwelt originally to the north of Mesopotamia, in a land less favorable to agriculture, spread westward and southward, driving out or subjugating the Turanian and Dravidian nations. Their speech, and those which are derived from it in Europe and Hindostan, show that they knew and transported several useful species. After these ancient events, of which the dates are for the most part uncertain, the voyages of the Phœnicians, the wars between the Greeks and Persians, Alexander's expedition into India, and finally the Roman rule, completed the spread of cultivation in the interior of Western Asia, and even introduced it into Europe and the north of Africa, wherever the climate permitted.

Later, at the time of the Crusades, very few useful plants yet remained to be brought from the East. A few varieties of fruit trees which the Romans did not possess, and some ornamental plants, were, however, then brought to Europe.

The discovery of America in 1492 was the last great event which caused the diffusion of cultivated plants into all countries. The American species, such as the potato, maize, the prickly pear, tobacco, etc., were first imported into Europe and Asia. Then a number of species from the Old World were introduced into America. The voyage of Magellan (1520-1521) was the first direct communication between South America and Asia. In the same cen-

tury, the slave trade multiplied communications between Africa and America. Lastly, the discovery of the Pacific Islands in the Eighteenth Century, and the growing facility of the means of communication, combined with a general idea of improvement, produced that more general dispersion of useful plants of which we are witnesses at the present day.

VEGETABLE MIMICRY AND HOMOMORPHISM

—ALEXANDER S. WILSON

BESIDES the family likeness and similarity of structure characteristic of closely allied organisms, other resemblances included under the terms Mimicry and Homomorphism, are observed among living things which can not be referred to a common ancestry since they are presented by plants and animals whose affinities are more or less remote. If the resemblance confers any benefit on either species it is spoken of as a case of mimicry, but if it results from the operation of general laws and is not directly advantageous, the likeness is described as homomorphic. It is not always possible to draw a sharp line between the two, and homomorphism not improbably represents one stage in the development of mimetic species.

The vital phenomena of plants and animals are so near akin that it would be strange if we did not meet with corresponding facts in the vegetable kingdom. Mimicry is perhaps more frequent in the seed than in any other part of vegetable organism; it oc-

curs, however, in other organs, and even the entire plant body may assume a deceptive appearance. A well-known example is the white dead-nettle, which so closely resembles the stinging nettle in size and in the shape and arrangement of its leaves. In systematic position the two plants are widely removed from each other, but they grow in similar situations and are easily mistaken; any one who has occasion to collect any quantities of *Lamium* is almost sure to get his hands stung by *Urtica*, an experience calculated to convince one of the efficacy of protective resemblance. Among animals it is species provided with formidable weapons of defence that are most frequently mimicked by weak defenceless creatures. The stinging nettle is therefore a very likely model for unprotected plants to copy.

A somewhat analogous case is the yellow bugle of the Riviera, which has its leaves crowded and divided into three linear lobes, some of which are again divided. In this the plant differs very greatly from its allies; it has, however, acquired a very striking resemblance to a species of *Euphorbia*, abundant on the Riviera. The acrid juice of the *Euphorbias* secures them immunity against a host of enemies. As the two plants grow together there is little room to doubt that, like the dead-nettle, the bugle profits by its likeness to its well protected neighbor.

The rare heath *Menziesia cærulea*, thought to be protected by its marked resemblance to the crowberry (*Empetrum nigrum*), has also been adduced as a probable case of mimicry.

Mr. A. R. Wallace in *Tropical Nature* refers to

the stone mesembryanthemum at the Cape described by Dr. Burchell, which closely resembles in form and color the stones among which it grows; on this account the discoverer believes this juicy little plant generally escapes the notice of cattle and wild herbivorous animals.

Mr. J. P. Mansel Weale mentions that in Karoo many plants have tuberous roots above the soil resembling stones so perfectly that it is almost impossible to distinguish them. The tubers of the potato itself in its native home may perhaps be protected in this way.

The last-mentioned observer has also noted a labiate plant, *Ajuga orphrydis*, in South Africa, which bears a strong resemblance to an orchid. As this is the only species of bugle in the district, Mr. Wallace thinks the flower profits by the mimicry and succeeds in attracting the insects required for its fertilization. A species of balsam at the Cape has also acquired an orchid-like aspect; *Tillandsia Usneoides*, one of the pineapple family, grows on trees in tropical America, and has a resemblance to a shaggy lichen so marked that it is generally mistaken for a plant of that order. The fly agaric, our most conspicuously colored fungus, according to Dr. Plowright, is closely imitated by a parasitic flowering plant, *Balanophora volucrata*, the scarlet cap, the dotted warts, the white stem and volva being all accurately represented.

The curious shapes of some exotic orchids are probably advantageous from their resemblance to insects and birds. One of our native orchids, *Lis-*

tua ovata, has a flower which in shape decidedly resembles a species of beetle, *Grammoptera lævis*, by which it is fertilized. Perhaps in this case the insect mimics the flower, as certainly happens with a pink-colored mantis in Java, which so exactly resembles a pink orchid that butterflies are attracted to it in mistake. The insect is carnivorous, and lies in wait for its prey, which is easily secured by the help of this strange disguise. Mutual resemblances of this description are rather characteristic of the *Orchidaceæ*. From their resemblance, real or fanciful, to butterflies, moths, bees, spiders, etc., various species of *Habenaria*, *Neotinea*, and *Ophrys* derive their names—the butterfly, spider, bee and fly orchises. In the orchid *Ophrys muscifera* are two little protuberances, regarded by the late H. Müller as pseudo-nectaries. Of this class of deceptive contrivances, however, we have a better example in *Parnassia palustris*, one of the saxifrages. This flower has five fan-like scales alternating with the stamens; the margins of the scales are fringed with hair-like processes, and each hair is capped with what appears to be a drop of honey. These are really hard, dry knobs, but so much do they resemble drops of honey that flies lick them before discovering the imposture. The intention of these sham nectar-drops may either be to decoy unprofitable guests from the real nectar, of which a limited supply is produced in the hollow of each scale, or to advertise it for the benefit of the more intelligent visitors.

Somewhat analogous to these pseudo-nectaries are the greenish swellings which arise on the veins of

the petals of *Eremurus*. These little swellings present a striking resemblance to aphides, or plant-lice, and Kerner states that a fly accustomed to hunt after aphides pierces and sucks the swellings, apparently mistaking them for the insects.

Relations which remind us of the pink orchid and mantis, mentioned above, seem to exist between the little bladders of *Utricularia* and the entomostracans. The bladderwort is a carnivorous plant with small submerged vesicles in which minute insects and entomostracans are caught. In shape these little traps of *Utricularia* are not unlike the body of a crustacean; the stalk corresponds to the tail, and near the entrance of each bladder are several antenna-like filaments so resembling certain appendages of the crustaceans that they impart to the structure a ludicrous resemblance to such an entomostracan as *Daphne*. This curious likeness was remarked by Mr. Darwin and can hardly be altogether accidental; perhaps the prey is more readily induced to approach the snare by reason of the resemblance. Here also may be mentioned the imposture practiced on its victims by *Darlingtonia*, another insectivorous plant. In the hood of its pitcher-like leaf are several transparent spaces through which the light shines into the interior; to these the imprisoned flies are attracted and thereby diverted from the only opening through which escape is possible. Mistaking the "windows" for real openings, the captives exhaust themselves in vain efforts to regain their liberty and are ultimately precipitated into the depths of the pitcher.

The flowers of the ox-eye daisy and the feverfew

are very much alike, and this was adduced by the late Mr. Grant Allen as a possible case of mimicry. But the probability is that in this instance the resemblance is merely homomorphic. The colors of flowers are distinctive as well as attractive. Where two species of plant grow together and are in blossom at the same time it is to their disadvantage to have the flowers of the one mistaken for those of the other. To secure cross-fertilization it is needful that the insect visitors pass from one flower to another of the same species, otherwise the pollen will be conveyed to the stigmas of the wrong species. It is of importance that the fertilizing agents should be able readily to distinguish different flowers, and this is no doubt one reason for the diversity of their colors, shapes, and odors. This circumstance must operate as a check against the production of mimetic blossoms; it will not, however, prevent flowers from acquiring a likeness to any object other than a flower.

Mimetic resemblances are much more numerous among fruits and seeds than in flowers. A very curious example is *Orphicaryon paradoxum*, the snake-nut of Demerara, inside which is the coiled embryo resembling a small snake. Among others mentioned by Lord Avebury are *Tricosanthes anguina*, the pod of which assumes a snake-like guise; *Scorpiurus vermiculata*, with pods in the form of a worm or caterpillar; *S. subvillosa* and *Biserrula pelecinus*, where the resemblance is to a centipede and certain lupines with spider-like seeds. The seeds of *Abrus precatorius*, *Martynia diandra*, *Jatropha*, the castor oil plant and the scarlet runner mimic certain beetles.

The presence of a caruncle representing the head of the insect renders the imitation more complete; this structure takes no part in germination, and Kerner is of opinion that it prevents the ants from attacking the substance of the seeds which they drag about from place to place. The ox-tongue and cow-wheat have worm-like seeds, and several plants have fruit difficult to distinguish from little pieces of dry twig. The jet-black, shining seeds and achenes of *Delphinium*, *Helleborus*, *Juncus*, *Atriplex*, *Polygonum*, etc., are easily mistaken for beetles; the brightly colored seeds of *Iris Germanica* are also in all probability mimetic.

The beautiful glossy scarlet and black piebald seeds of *Abrus* known as rosary beans perhaps escape destruction through birds mistaking them for some nauseous insect gaudily attired in warning colors. But from the manner in which the seed vessels of *Iris* and *Arbus* dehisce and expose their seeds the brilliant colors of the latter would appear to subserve dissemination rather than protection. Such hard seeds are probably dispersed through the agency of insectivorous birds, which seize them in mistake for their more legitimate prey. According to Lord Avebury, the beans of *Abrus* mimic the beetle *Artemis circumusta*. The smaller seeds, known as crab's eyes, are colored in an analogous manner. These cases are the less surprising if we have regard to the fact that the majority of dry fruits, though green while growing, become black or brown when they fall to the ground, so that their general tint corresponds with their surroundings and tends to concealment.

The odors of fungi are very varied. *Clathrus* and *Phallus* are offensive and attract swarms of blow-flies; *Lactarius* and *Hydnum*, on the other hand, are sweetly scented like the flowers of *Melilotus*. Among the odors of fungi enumerated by Dr. Plowright are those of aniseed, mint, peppermint, garlic, horseradish, cucumber, ripe apricots, rotting pears, rancid herring, Russia leather, gas-tar, prussic acid, nitric acid, and cacodyl. Like the hemlock, *Agaricus incanus* has the smell of mice, two species of *Lactarius* have the odor of the common house-bug, while *Hygrophorus cossus* smells like the larvæ of the goat-moth. Fifteen or sixteen species of agaric resemble oatmeal both in taste and smell, *Hydnum repandum* has the flavor of oysters, recalling the oyster plant among the *Boraginaceæ*, whose leaves have a similar taste. Several are possessed of a nut-like flavor. The common stinkhorn, *Phallus impudicus*, is the best known representative of a large family of fungi, the members of which are found in various parts of the world. The *Phalloidi* include *Phallus*, *Lysurus*, *Simblum*, *Clathrus*, *Aseröe*, and other genera, all characterized by offensive odors and conspicuous colors. These fungi have been carefully studied by Mr. T. Wemys Fulton, whose paper on the *Dispersion of Spores in Fungi* in the *Annals of Botany* for 1899 contains many interesting and important observations bearing on mimicry.

The rapid elongation of the stinkhorn is very remarkable; the fungus has been observed to attain a height of several inches in half an hour, furnishing an apt illustration of the proverb that ill weeds grow

apace. It not only emits an intolerable charnel-house stench, but its ghastly pallid hue seen against the background of its usual surroundings is peculiarly suggestive of the dead carcass of some animal. Its surface at first exudes a sweetish slime containing sugar, but the hymeneum or spore-bearing portion is deliquescent and the entire mass speedily undergoes a series of changes, the white becoming brown, then black, the solid mass being ultimately resolved into a dark fetid fluid in which the spores are suspended. These mimetic changes, which so closely approximate to those of decomposition, attract carrion flies in prodigious numbers. Blow-flies even deposit their eggs on the fungus, and the maggots seem to develop as though nourished by its substance. On examination Mr. Fulton found the spores adhering in thousands to the feet and proboscides of the insects. Their excrement he found to consist almost entirely of spores, and the latter were found by experiment to be still capable of germination. There is therefore no doubt in this case that flies are employed as agents in the dispersion of the fungus. This statement also applies to various Coprini and others with a deliquescent hymeneum.

Quite a number of flowers have distinctly mimetic odors. It can hardly be doubted, for example, that the offensive smell of the carrion flowers *Stapelia*, *Aristolochia*, *Arum*, *Rafflesia*, and others, is more effective in promoting cross-fertilization because of its resemblance to the odor of putrid meat. So completely are the flesh flies deceived that they often deposit their eggs on the petals of carrion flowers.

Fetid odors occur in *Bryonia*, *Helleborus*, *Geranium*, *Stachys*, *Ballota*, *Iris* and other genera. The odors of others have a curious resemblance to the smells emitted by certain animals. *Hypericum hircinum* and *Orchis hircina* are bad smelling flowers with an odor resembling that of the goat; *Coriandrum sativum* has the fetid smell of bugs, while the hemlock, again, emits a strong odor of mice. Along with these may be mentioned *Adoxa*, the musk orchis, the grape hyacinth, and other musky-scented flowers.

The resemblance in smell between these flowers and the secretion formed in the scent glands of the musk ox and other animals is, to say the least, a remarkable coincidence. Possibly flies which accompany cattle may be attracted by smells of this description. Very curious also is the vinous smell of *Oenanthë*, and the brandy-like aroma of the yellow water lily *Nuphar*, hence called the brandy bottle. Ethereal oils exhaled by plants while attractive to some animals seem to repel others; the scents of sweet-smelling flowers such as *Daphne*, *Thymus*, *Marjoram*, *Melilotus*, and *Gymnademias*, though grateful to bees and butterflies, appear to be distasteful to ruminants. Kerner states that in general the latter avoid all blossoms; even caterpillars do not readily attack the petals of their food plants. Odor may therefore be protective or attractive or it may be of use in both ways. The same remark applies to color, which may serve either to attract or repel; the richly variegated leaves of the Indian nettles—species of *Colletes*—and the tinted foliage of *begonia* and *geranium* may possibly escape injury on ac-

count of the general resemblance to colored blossoms. Instances in which one plant resembles another in smell are not very common in the flowering class, though cases do occur like the garlic, mustard and apple-scented *Salvia*. Resembling odors are much more frequent among fungi.

Characteristic examples of homomorphism are seen in the resemblances which many species of *Euphorbia* present to the cactus tribe and in the pollen-masses of the orchids and *asclepias*. In Britain the order *Euphorbiaceæ* is represented by the box, dog's-mercury, and the sun-spurges, but many foreign species have quite a different appearance and agree with the cacti in their aborted leaves and green succulent stems. The globular, columnar, and angular forms give to both a peculiar aspect by which they are broadly distinguished from all other vegetable types; and yet in systematic position these two orders stand far apart. The nearest affinities of the *Euphorbiæ* are with the *Urticaceæ* and other orders having incomplete flowers, while the nearest allies of the *Cacti* are the *Cucurbitaceæ* and other calycifloral orders. Succulent stemmed plants of this description are specially adapted to an arid climate, and it is not unreasonable to suppose that the similarity between the *Euphorbiæ* and *Cacti* results from the long-continued action of similar external conditions upon similarly endowed tissues.

The Australian *Casuarinas* are dicotyledons with incomplete flowers nearly related to the oak, hazel, and other *Cupuliferæ*, but in outward appearance they have a singular resemblance to the horse-tails, a

family of cryptogams. One of the gymnosperms or cone-bearing class, *Ephedra*, also presents the same jointed appearance so characteristic of *Equisetaceæ*. Growing in marshy places very like those affected by *Equisetum* we find the mare's-tail *Hippurus*, a flowering plant allied to the fuchsia family, but externally resembling *Equisetum* in its jointed stem and whorled leaves. A familiar instance of the same kind of homomorphism is *Equisetum sylvaticum*, which might almost be described as a liliputian fir-tree. The little flowers of the water ranunculus look exactly like miniature water lilies, while the leaves and flowers of *Caltha palustris* simulate the yellow *Nuphar* so much that in some parts of the country the marsh marigold is known as the water lily. The specific name of another aquatic, *Lymnanthemum nymphaeoides*, indicates a peculiarity of the same kind. Leaf analogies are frequent among aquatic plants; the orbicular, peltate leaf of the Indian cress occurs, for example, in *Hydrocotyle*, *Nelumbium*, and others. The brown color and translucence of *Potamogeton*, *Myriophyllum*, and other aquatics assimilates them to the fronds of *Laminaria* and other sea-weeds.

A grass-like habit is assumed by some plants. This character is attained in the meadow vetchling by the arrested development of the compound leaves and the great elongation of the stipules. *Lathyrus nissolia* has the stipules minute, but the phyllodes or leaf-like petioles impart the grass-like character. A moss-like habit occurs in a great many plants belonging to very different families; thus the wiry stem of

the purging flax reminds one of the seta of *Polytrichum*. The pearlwort of the walls, many alpine saxifrages, pinks, and gentians present very much the appearance of mosses, *e. g.*, *Silene acaulis*, *Saxifraga bryoides*, *S. hypnoides*, *Arenaria Cherleri*, etc. The sub-species *Saxifraga geum* is another instance of leaf analogy. The generic name *Pyrola* implies a fancied resemblance of the leaves to those of the pear tree. Certain leaf-types frequently recur, the rough broadly tongue-shaped leaf of the bugloss, for example; hence the very common specific appellation *echioides*. The nettle-leaved bell-flower reproduces the foliage of *Urtica* and the sinuate leaf of the oak appears in several families.

Parasitic phanerogams like *Rafflesia* commonly exhibit the fungoid character in a marked degree. In their internal structure, coloring, spore-like seeds and other characters they approximate closely to the fungi.

As examples of homomorphism between closely allied plants may be mentioned the false oat, which so strikingly resembles the cultivated species, and the barren strawberry, which agrees so closely with the cultivated strawberry of our gardens.

Although it is only under exceptional circumstances that a flower is likely to mimic another blossom closely, vague general resemblances are not uncommon, such as that between the rock-rose and the buttercup, between the milkwort and the vetch, and between *Veronica* and *Valerianella*. A more decided likeness is that of the garden annual *Collinsia* to the butterfly blossoms of the pea tribe. This case

is peculiarly instructive since the homomorphism can be traced to its cause. The butterfly-like corolla of Leguminosæ seems to have afforded the pattern after which a number of flowers have been fashioned. The Papilionaceæ are adapted to bees rather than to butterflies or moths, and the pollen is applied to the ventral surface of the insect, the essential organs being lodged in the carina or pouch formed by the two lower petals. Among the Scrophulariaceæ to which *Collinsia* belongs, the pollen is commonly sprinkled on the back of the insect and the stamens are contained in the upper lip of the corolla; *Collinsia* is, however, exceptional; the stamens are lodged within the lower lip of the flower and the pollen is applied to the ventral surface of the bee. Here the resemblance is evidently an indirect result brought about by the flowers of *Collinsia* having become adapted to the same class of visitors as the Papilionaceæ, viz., bees which have their brushes or baskets of hair for collecting pollen attached to the abdomen. Where two flowers are very like insects are apt to mistake the one species for the other, but this will not involve any loss if there is an interval between their periods of blossoming.

Homomorphic likenesses are not confined to homologous organs; an organ of one plant sometimes exhibits a perfect resemblance to a different organ on some other plant. Thus *Aristolochia siphon*, the Dutchman's pipe, so-called from the appearance of its flowers, has a perianth singularly like the leaf-pitchers of *Nepenthes*, and the curious little nectaries of *Nigella* might almost be compared with the

pitchers of the Australian insectivorous plant *Cephalotus*. As the *Aristolochias* imprison small dipterous insects in their flowers these instances favor to some extent Henslow's idea that both flowers and pitchers have arisen by hypertrophy caused through the irritation set up by insects.

The homomorphism of the orchids and asclepiads is especially interesting because of the objection to the Darwinian theory that it presents; the coincidence is certainly unfavorable to the notion of fortuitous variation. The orchids and asclepiads agree in producing pollinia or pollen-packets which attach themselves to the bodies of insects and are thus transferred from flower to flower. Although the two flowers differ greatly in the details of their structure, this curious contrivance occurs in no other plants, and yet the two orders are as widely separated as it is possible to conceive. The orchids belong to the petaloid division of Monocotyledons; the asclepias to the gamopetalous Dicotyledons, with their nearest allies among the Apocynaceæ, of which *Vinca*, the periwinkle, is perhaps the best known representative. Although agreeing in this one particular, the flowers are in other respects very dissimilar.

Another contrivance for promoting cross-fertilization met with in unallied plants is the mouse-trap arrangement of hairs by means of which small flies are temporarily imprisoned. This arrangement occurs in *Aristolochia*, in species of *Arum*, and in *Ceropegia*, one of the asclepiads. In these plants, where the affinities are so slight, the mechanism for fertilization must in each case have arisen independently.

THE BAMBOO AND PLANT GROWTH.—R. CAMPER DAY

IF the many families of flowering plants were arranged in the order of their utility to man or in the order of their abundance, the first place in the list would unquestionably be assigned to the great family of grasses. Of their omnipresence and abundance some idea may be obtained from the fact that at least four thousand different kinds have been described, and a German naturalist has estimated that they constitute a twenty-second part of all known plants. Their utility as food producers becomes obvious as soon as we recall the names of rice, wheat, barley, oats, rye, and Indian corn, and remember how large a proportion of our food is made from their seeds. Most of these civilized and somewhat unnatural grasses have been so long under cultivation, and so much altered by man's selection, that they are totally unfitted to shift for themselves, and would soon become extinct if brought into competition with wild plants. The fact that the wild forms from which they are descended can not now be identified with certainty shows that their cultivation must date from the very earliest ages. Rice alone is said to furnish more sustenance to the human race than any other single species; the common meadow grasses, such as the purple-tipped *Anthoxanthum*, which fills the fields with its penetrating fragrance when the hay is newly mown, are almost the only food of sheep and cattle; and those

tall and sturdy canes whose juice we squeeze out between rollers, and clarify and crystallize into sugar, are only modified stems of grass.

The largest of the family, and perhaps the most beautiful, is the tropical arborescent grass which bears the name of bamboo. Although it is not cultivated for the sake of its seed, it has many admirable qualities, and wherever it grows in abundance it is applied to a variety of uses. "The strength, lightness, smoothness, straightness, roundness, and hollowness of the bamboo," says Mr. A. R. Wallace in his *Malay Archipelago*, "the facility and regularity with which they can be split, their many different sizes, the varying length of their joints, the ease with which they can be cut and with which holes can be made through them, their hardness outside, their freedom from any pronounced taste or smell, their great abundance, and the rapidity of their growth and increase, are all qualities which render them useful for a hundred different purposes, to serve which other materials would require much more labor and preparation. The bamboo is one of the most wonderful and beautiful productions of the tropics, and one of nature's most valuable gifts to uncivilized man."

In order that the accuracy of this eulogy may be appreciated, let us imagine the case of a shipwrecked man landing without any tools, except an axe and a knife, upon an island in which we will suppose the bamboos are the only vegetation, and let us see how far he could supply his needs with their assistance. One of his first requirements would be a house, and

this could be provided with very little labor. The stems of one of the larger species, such as *Bambusa Brandisii*, driven into the ground, would form excellent uprights for the framework, which could be completed with lighter cross-pieces nailed to the uprights with pegs of the same material. A good roof could be made by taking broad strips split from large bamboos, and fastening them side by side with their concave surfaces uppermost, the interstices between them being covered with other pieces having their convex sides uppermost. Similar but flatter pieces laid upon the joists, and tied down firmly with strips shredded from the outer rind, would form a smooth and elastic floor such as could not be made out of other materials without a great expenditure of labor. Thin strips plaited together, or broad strips pegged side by side, might be used for the walls.

The furnishing of the house would be an easy matter, for bedsteads, chairs, brooms, baskets, cords, fans, bottles, mats, and hoes can be made of bamboo with the greatest facility. The water-tight joints of the stems form admirable water-vessels, and it would be easy to bring the water to the very door by a gently sloping aqueduct of pieces of bamboo split down the middle and supported at intervals on cross-pieces arranged like the letter X. The jars made from the joints could be utilized not only for holding water, but even for boiling it. Mr. Wallace tells us that rice, fish, and vegetables can be boiled in them to perfection. The young shoots of the bamboo as they first spring from the ground are said to be

a delicious vegetable, "quite equal to artichokes." That fish may be readily caught by the agency of the bamboo is shown by the many specimens of ingenious fish-traps exhibited in the museum at Kew. If we suppose our adventurer to take a thin stem of bamboo, and cut off the end obliquely just above a joint so as to leave a sharp edge, he would be provided with a hard-pointed and very efficient spear. In the same way he could supply himself with daggers and arrows; while from the more elastic species he could make himself a bow, using a thin strip of the outer rind for a bow-string. The lowest internode of *Arthrosyldium Schomburgkii*, which sometimes attains the extraordinary length of sixteen feet, far surpassing the length of the joints in all other bamboos (says General Munro), furnishes the "Sar-bican" or blow-pipe through which poisoned arrows are blown by the natives of Guiana. In the island of Celebes the only article of dress worn by the natives is a body-cloth called Kian Pakkian, made of bamboo split into fine shreds, which are passed between the teeth and bitten until they are soft, when they are woven.

If, after providing himself with these and similar necessities, our shipwrecked man found leisure to amuse himself, he might make æolian flutes, such as Sir Emerson Tennant saw in Malacca, by boring holes in the stems of living bamboos, or he might construct a harp like that in the Kew Museum, London, which was brought from Timor by Mr. Wallace. This harp is made from a cylinder of bamboo having a node at each end. Under a strip of the outer rind

a quarter of an inch wide, a sharp knife is passed so that the strip is detached from the cylinder except at its two ends. The strip forms one of the harp strings. Two small wedges are pushed under it, and the portion between the wedges can be sounded like the string of a guitar. It is also possible, and not very difficult, to make such diverse articles as paper, pens, waterproof clothing, hats, wax, pickles, bird-whistles, rafts, pillows, fermented drink, and bridges from the same versatile vegetable. In the Kew Museum, which should be visited by every one who wishes to see the varied uses to which bamboos can be applied, perhaps the most curious article is a headman's knife brought by Mr. Franks from the southeastern peninsula of New Guinea. This singular implement, which is shaped like a cheese-scoop and seems very ill-adapted to its purpose, is marked with numerous notches, each notch representing one of its victims; and it is accompanied by an artistic apparatus, also of bamboo, intended apparently to enable the executioner to carry the severed head.

The bamboo usually grows in a cluster of from ten to a hundred stalks, and springing from the same rhizome or root-stock. The rhizome is not the root, but an underground portion of the stem. It consists of a number of segments about the size and shape of a banana and somewhat bloated in the middle. The banana-like segments are joined together irregularly by their tips, so that the whole rhizome forms a strong underground trellis-work admirably adapted to support the light and yet rigid stems that rise up

from it. From the under side of the rhizome spring downward the true root-fibres, numerous as the bristles of a broom.

The stem itself, as every one knows, is smooth, polished, and cylindrical, and is divided into air-tight compartments by knots or nodes, which are the points at which the fibres of the stem cross over from one side to the other. The lowest ten nodes or so are usually bare, but from the upper nodes issue branches. These are very slender as compared with the main stem, and carry the foliage leaves. In most species the leaves are rather small, but in some they are very large. The species named *Planotia nobilis* by General Munro, a native of New Granada, has the largest leaves of any kind of grass; they are often a foot in diameter and fifteen feet in length.

The most important part of the bamboo, from a botanical point of view, is the flower, which roughly resembles the flower of our common grasses. The flower of grass is inclosed in hard, scaly leaflets called glumes; it usually has three stamens and one seed-vessel. There may be only one flower inclosed in the glumes (as in foxtail grass), or more (as in wheat). The flowers of the bamboos, while on the whole conforming to the grass type, exhibit many small differences in different species. In some kinds, as in *Arthrostylidium longiflorum*, the inflorescence resembles a bunch of ears of wheat; in others, as in *Bambusa vulgaris*, the flowers are packed into round clusters; in others, as in *Chusquea simpliciflora*, they are in threes and fours, each flower hanging by a separate slender stalk. The seed

generally resembles oats or wheat, but in some species it takes the form of a berry, not unlike the seed of our familiar pimpernels. In the species known as *Molocanna*, the fruit is exceptionally developed, often attaining the size of a largish pear. Some species flower and die down annually; others flower annually, but live on; as a rule the bamboo grows for many years without flowering, and then suddenly bursts into bloom. From the fact that the number of years between the sowing of the seed and the flowering of the plant varies, and that in some years nearly all the bamboos in a given district flower simultaneously, it would seem as if the blossoming does not take place at any prescribed age, but may occur at any period after the plants reach maturity when a favorable season supervenes. It used to be thought that after a general flowering of the bamboos throughout a district all the plants died, but this view proves to be incorrect. The flowering shoots usually die, and during the flowering the foliage almost entirely disappears, but the entire plant is not necessarily killed.

The Chinese have a proverb that the bamboo produces seed most abundantly in years when the rice crop fails, and several curious cases of the truth of this saying have been recorded. According to General Munro, in 1812 the universal flowering in Orissa prevented a famine. Hundreds of people, he says, were on the watch day and night to secure the seeds as they fell from the branches. Another instance occurred in 1864, when there was a general flowering of the bamboo in the Soopa jungles, and

very large numbers of persons came from the neighboring districts to collect the seeds.

In most bamboos, the stem is characterized by straightness, smoothness, roundness, and quickness of growth, no doubt because these qualities have, as a rule, proved serviceable to the plant in the struggle for existence. Light and air being necessary to the life of grass, it is manifest that in the dense vegetation of the tropics a plant which can push itself rapidly to a great height must have an advantage; and in order that growth may be rapid and the plant spring up to a considerable height without climbing, it is essential that there should be as little material as possible in the stem, and yet that it should be as strong as possible. It is difficult to imagine a stem in which these conditions would be better fulfilled than in that of the bamboo. By reason of its hollowness the amount of material is reduced to a minimum; and by reason of its cylindrical shape, its nodes, and the hardness of the outer rind, the strength of the structure is at a maximum. The growth is consequently very rapid, an increase in height of 2 to $2\frac{1}{2}$ feet having been recorded in a single day. The *Bambusa Brandisii* often measures as many as 120 feet, and is said to attain its full altitude in a few months.

But although, as a general rule, the necessities of natural selection have ordained that bamboos shall be perfectly straight and perfectly round, this archetypal form or idea (to borrow a word from Plato) does not always hold good. One species, found in Asia, is said to have crooked and even

creeping stems. Another, found in Ecuador, is described by General Munro as being distinctly a climbing plant. There is a species, recently described by Mr. Thiselton Dyer, with a stem exactly square, and as well defined as if cut with a knife. It has only lately been found in China, where it is grown chiefly for ornament.

According to Mr. Dyer, the Chinese account for its squareness in the following way. They say that in the Fourth Century A. D., the famous alchemist, Ko Hung, took his chopsticks (which consist of slender rods of bamboo pared square) and thrust them into the ground of the spiritual monastery near Mingpo; and then by his thaumaturgical art he caused them to take root and appear as a new variety—the square bamboo.

The growth of plants is one of the greatest mysteries of nature, and nothing is more mysterious in their growth than their limited but very definite power of movement. How is it that some plants grow vertically upward, like the normal bamboo, others climb and twist, others creep, and others grow in zigzag shapes? How is it that some turn toward the light, some away from the light, while others place themselves at right angles to it? And how is it that if you peg down the young stem of a vertically growing plant it will bend upward beyond the peg? No doubt the proximate cause is natural selection; they do these things because they have found them advantageous. But this does not tell us by what mechanism a plant is enabled to keep on growing in the particular direction which it finds

advantageous. We know that when a plant bends in a given direction, the cells on the convex side of the bend are more turgescient, that is, more distended with sap, than those on the concave side, and that the increased turgescence of the former is followed by increased rapidity of growth; but what causes the distribution of turgescence in the cells has not been clearly made out. It seems probable, however, that when a shoot is growing in its proper and natural direction, the chief force which guides it and enables it to maintain that direction is the force of gravitation. To this force the growing portions of a plant are extremely sensitive. Consider, for example, the case of a vertically growing shoot. Whenever it is accidentally bent the force of gravity must evidently act upon the portion above the bend, tending to curve it still more, and causing a strain in the material of the stem. The plant in some mysterious way is aware of this strain, and the cells of the lower side of the bent portion are stimulated to increased turgescence as compared with those of the upper side, so that the under side would grow faster; and as the plant would turn upward in consequence, any deviation from the perpendicular would tend to correct itself. Similarly a shoot which grows horizontally is led by the same stimulus of gravitation to rectify any departure from a horizontal position. Gravitation, then, does not *cause* the bending when a displaced shoot endeavors to regain its normal direction, but serves merely as a guide. By its means the plant is made aware (so to speak) that it has been displaced, and takes measures ac-

cordingly. If the force of gravity were absent, the shoot would go on growing in any position in which it might happen to be placed. This may be proved by causing a growing seed to revolve slowly round a horizontal axis, so that at every revolution the force of gravity may act upon it equally in all directions. When a shoot is grown in these conditions, it is found that its power of correcting deviations from any particular line of growth is lost. Similar reasoning applies to the action of light on plants, but, as above stated, we do not know why it is that plants respond to the stimulus of light or gravity; we only know that as a matter of fact they do so.

It has often been vaguely asserted that plants are distinguished from animals by not having the power of movement. It should rather be said that plants acquire and display this power only when it is of some advantage to them; but that this is of comparatively rare occurrence, as they are affixed to the ground, and food is brought to them by the wind and rain. We see how high in the scale of organization the plant may rise when we look at one of the more perfect tendril-bearers. It first places its tendrils ready for action, as a polypus places its tentacula. If the tendril be displaced, it is acted on by the force of gravity and rights itself. It is acted on by the light, and bends toward or from it, or disregards it, whichever may be most advantageous. During several days, the tendril or internodes, or both, spontaneously revolve with a steady motion. The tendril strikes some object, and quickly curls round and firmly grasps it. In the course of some hours it con-

tracts into a spire, dragging up the stem and forming an excellent spring. All movements now cease. By growth the tissues soon become wonderfully strong and durable. The tendril has done its work, and done it in an admirable manner.

THE REIGN OF EVERGREENS.—GRANT ALLEN

THE poor stripped and draggled garden is beginning to look very bare now (November) of all except a few straggling late-flowering shrubs and those trusty adopted friends that we have always with us, the shrubby, large-leaved southern evergreens. In northern climates, we must ruefully admit, there are hardly any true evergreens, save only the conifers, with their stiff and needle-like foliage, such as pines and spruce-firs; but we make up for it to some extent by borrowing from warmer or more southern lands the laurels, aucubas, laurustinuses and rhododendrons, that help to keep bright our English lawns and shrubberies throughout the long and weary winter months. Indeed, our only native flat-leaved shrubs that retain their full greenness from year's end to year's end are privet, box, and butcher's broom, all three of them very doubtfully indigenous to these islands. It is the rule with English trees and shrubs to shed their foliage every autumn; and the fashion in which they do so shows very clearly how purposive and well adapted to their conditions in life is the deciduous habit. For the leaves do not merely tumble off any-

how, casually, before the first fierce autumnal winds; if they did so there would be loss of sap and of valuable foodstuffs to the whole plant of whose joint commonwealth they form the partially dependent members: their fall is duly provided for beforehand, and when at last it actually takes place, it takes place in an orderly and regular fashion, with the least possible injury to the interests of the entire tree. From the very beginning there has been arranged at the joint where the leaf stalk joins the stem, or where the separate leaflets join the central mid-rib, a row or articulation composed of cellular tissue, and specially designed to act as a joint for the dry leaves. When winter approaches, and chilly northern winds are likely to tear to pieces the leaves on the trees, all the protoplasm and other valuable cell-contents are withdrawn into the permanent tissues of the plant, leaving only the minor red and yellow coloring matters (mostly effete and used-up foodstuffs) which give so much beauty and glory to the general aspect of our autumn woodlands.

Then the articulation dries up and withers, and the dead leaf separates at the joint, leaving behind it a regular mark or scar, which is the visible token of Nature's definite precaution against the northern cold and tempests.

It was not always so, however, and it is not so even now in the greater part of the modern world that we ourselves inhabit. It seems quite natural to us northerners that "leaves have their time to fall"; so natural, indeed, that we almost forget the strict limitation of the practice to our own chillier lati-

tudes. Yet in reality the existence of deciduous trees is a mere temporary accident of the here and the now, a passing consequence of the great cold spell which had its culminating point in the last glacial epoch, and from whose lasting effects we ourselves are even still apparently suffering. Whether, as Mr. Alfred Russel Wallace seems hopeful enough to believe, our poor old planet may yet recover from this premonitory chilling or not, whether we may yet look forward to a few more warm spells or otherwise, before the final numbness of all dying worlds comes upon us, is a question rather for the consideration of astronomers and physicists than the mere mundane-roving naturalist, with his petty ephemeral interests in our plants and animals; but one thing at least is certain, that till a very recent period, geologically speaking, our earth enjoyed a warm and genial climate up to the poles themselves, and that all its vegetation was everywhere evergreen, of much the same type as that which now prevails in the modern tropics. Indeed, we have only to look at the existing state of things in order to see how very slight is the effect that has thus been produced upon our temperate flora. For example, among the oaks alone, there are some twenty species in Europe, of which Southern Europe has eighteen, mostly evergreen, while north of the Alps there are only two, or at most three, all of them deciduous. From the evolutionary point of view it is clear that the northern kinds are modern developments, specialized to contend with the peculiarly cold conditions of sub-Arctic Europe.

Fortunately, too, we are not left in this matter to mere conjecture or analogy: thanks to the researches of Heer and others, we have positive geological facts to guide us which show conclusively that up to the Miocene period Europe was covered by forests of large-leaved evergreen trees, of what we should now consider distinctively tropical types. Ever since the Miocene, and on to the culminating point of the great Ice Age, the European climate has been growing steadily colder, and the European flora has been at the same time steadily adapting itself to the new conditions, and to assuming what we now consider a typically northern aspect. During all that time, the large-leaved evergreens gave way before the deciduous trees and the chillier conifers, beginning at the north pole and spreading gradually southward, as the cold deepened and widened its range. Since the end of the great Ice Age, and the subsequent slight amelioration of the climate in Northern Europe, a reverse process has begun to set in; the Arctic types have begun to recede slightly once more, and the comparatively southern or temperate types have pushed their way northward to occupy the place from which they were previously dispossessed by the newly evolved kinds. It is not necessary for us to inquire here into the causes of this great cycle; the facts are there, and for our present purpose they are quite sufficient. They show conclusively, when one follows them out in detail, that the evolution of deciduous trees was concomitant with the growth of cold conditions around the two poles; and that such trees now exist only where winter, for part

of the year, renders the evergreen condition an undesirable one. Even in the tropics, indeed, we find on high mountains a belt of deciduous forest, stretching above the belt of large-leaved evergreens, which itself succeeds to the lowland palms and tree-ferns of the thorough-going equatorial plains.

The reason for the evolution of deciduous trees is of course to be found in the peculiar circumstances of the circumpolar regions. In the tropics, trees and plants can thrive and blossom all the year round; and even in temperate countries most small herbs and weeds gain by keeping their foliage throughout the winter; but big trees in cold climates would suffer much by the tearing and strewing of their leaves in winter gales, while they would obtain little advantage by retaining them on the tree during the long chilly season. Hence, if any tree happened to possess any arrangement by which dead or dying leaves could be removed without injury to the permanent tissues, while, at the same time, the useful materials were withdrawn into the young bark to await the spring awakening, such a tree would obviously enjoy an advantage in the struggle for existence, and would be likely to outstrip its evergreen neighbors in rigorous climates. Now, as a matter of fact, the germ of such an arrangement is found even in many herbs or small shrubs, such as, for example, the common pelargoniums or "scarlet geraniums" of our flower-gardens. Everybody who has ever kept these familiar plants in his own rooms must have noticed how easily the dead leaves separate from the stem at their base, by means of the swollen cel-

lular mass where the leaf-stalk joins the axis. All that the forest trees of northern climates had to do, then, was just to take advantage of this nascent provision, wherever it existed (mark this prior necessity), and render it more fixed under the influence of natural selection. But if we may judge by the actual sequel, it was not every kind of tree that could adapt itself to the altered circumstances; as a matter of fact, the number of species among northern forest trees is very small indeed, and even out of this small number a good many are conifers, like the pines and yews, whose narrow tough leaves are well fitted for withstanding and battling against all the winter breezes. Still, among the conifers themselves there are a few species, such as the larches, with tender, delicate foliage, which have also become deciduous under stress of altered conditions. At the present day the large-leaved and flat-leaved evergreens are mostly confined to tropical, sub-tropical, or at least warm temperate climates, and all the forest trees or the circumpolar tracts are either deciduous, or else are tough leathery-leaved conifers. The laurels and rhododendrons, with which we strive artificially to brighten up our comparatively leafless English winter, are either hardy representatives of the warm temperate flora, or else mountain species from southern climates, with constitutions just strong enough to endure our chilly season in favored and carefully selected situations. Such evergreens have generally very rigid and shiny leaves to protect them—a point well marked in ivy and laurel as compared with Virginia creeper and English hawthorn.

OUR MICROSCOPIC FOES

—A. WINKELRIED WILLIAMS

OF all the foes that are waging war against mankind, the most dangerous and deadly are minute organisms belonging to the lowest order of plant-life, and invisible to our naked eye. An immense number of these always surround us, and are ready to make an attack should they find a weak point in our defences.

Their presence in the air may be readily demonstrated by exposing some material upon which they can feed, and watching the result. The simplest method is to boil a potato, cut it in half, and immediately place one-half under a bell glass purified by being washed in an antiseptic solution such as corrosive sublimate. Expose the second half to the open air for a short time, and place it also under a glass. Let them remain for a few days, and then examine. If the first half has been placed rapidly enough under the glass, we shall find it unaltered. On the second half, however, we shall see a number of small but growing spots, which will probably vary much in color. These consist of colonies made up by immense numbers of most minute plants, *i. e.*, bacteria, and also of higher fungi. Certain species of the bacteria constitute our dreaded foes.

Bacteria are non-nucleated unicellular plants, which may be roughly classed into two divisions according to their shape, the circular forms being called micrococci, the elongated forms bacilli. In

size, they are most minute, being only visible under the highest powers of the microscope. Many are provided with cilia, by the lashing of which they are capable of independent movement. They are composed of a peculiarly resistant protoplasm, which is condensed at the surface, so that by the action of certain caustics they can be separated from many tissues on which they may be lying, the caustics destroying these tissues.

Bacteria have enormous power of reproduction, which is accomplished by division of the cells and fission. Many also form globular spores by a condensation of their protoplasm. The spores have a much higher power of resistance than the bacteria themselves, and may under unfavorable circumstances be quiescent while awaiting better times to take on full development.

Their *habitat* is almost everywhere. In water, bacteria exist in great numbers; they are even found in springs at their sources. This indicates their presence in the soil, where they are found in great numbers. We have already seen that they exist in the air, but being, for their size, heavy bodies, they are invariably attached to less dense particles of dust. Out at sea, we find the air free from bacteria, although in the water they abound. The higher we ascend, the fewer we find. In towns, the air teems with them; in the country but few exist. In the healthy living body, there are no bacteria, except in the alimentary canal and upper respiratory passages. It must not be supposed that all bacteria are the forerunners of disease; such is the case with only cer-

tain forms to which the significant term pathogenic bacteria is applied. Many authorities assert that the non-pathogenic forms may, under certain circumstances, develop into pathogenic forms. This, however, has not been definitely settled, since we are only able to separate the different classes of bacteria by their action on cultivating media and on the living body. We have not yet been able to develop by cultivation a virulent form from a non-virulent, although we have by repeated cultivation diminished the virulence of the most malignant bacteria.

Of all the pathogenic bacteria we have the most direful tale to tell. Of one, discovered by Dr. R. Koch—namely, that of tubercle—the terrible ravages on human life by ferocious animals in India (over 24,800 fatalities per annum) are but trifling compared to the ravages stealthily done in our midst by this the smallest of the class of most minute living units. According to Dr. Koch's estimate one-seventh of the human race die of pulmonary consumption, and this is only one, certainly the most prolific, of the many diseases directly caused by the tubercle bacillus.

Happily for warm-blooded animals, these terrible death-dealers differ from most other bacteria, for although they can remain alive for some time outside the body, they are unable to develop in the outside world, and this considerably limits their number. A temperature above 96° Fahr. is necessary for their growth, and there are only a very few soils on which they can be cultivated, such as blood-serum and meat jelly. Moreover, they develop more slowly

than other known bacteria, which may consequently outgrow them, and prevent their development. How, then, are we to account for the fact that tubercle is such a widely spread disease, not only among all the races of men, but also among many of the lower animals? The consideration of the following facts answers this question.

The tubercle bacillus can form resting spores; consequently, when once the tissues of a part have their vitality so lowered that the entrance of the bacilli is allowed, they can retain their hold with great tenacity. Although the bacilli can not develop outside the body, their vitality is preserved for a long time. Certain animal products used for food, such as the milk of tubercular cows, contain the bacilli. Experiments such as causing animals to inhale the tubercle bacilli, or the introduction of them into the blood, or sometimes the feeding on tubercular matter, result in tuberculosis.

Pulmonary consumption presents an example of the most typical way in which the tubercle bacillus performs its deadly work. In the majority of cases, the bacilli are inhaled with the air, but may also infect the lungs from the blood carrying them from tuberculosis in other parts of the body. The bacilli are incapable of independent movement. This difficulty is too readily overcome in the body, as the streams of blood and lymph easily carry them along.

Their movements in the body may be aided by certain scavengers that are crawling about in our tissues and circulating in our blood; namely, the wandering cells of connective tissue and the white

blood corpuscles. These take up the bacilli by wrapping their substance around them; then, for a time, they crawl about carrying with them the bacilli. In this attempt to devour the tubercle bacillus, they often find they have caught a Tartar, who in turn feeds and multiplies in them, and thus their wandering days soon end.

Many other diseases are known to be caused by bacteria, such as anthrax, cholera, pneumonia, typhoid fever, erysipelas, leprosy, suppuration, and ordinary blood-poisoning. Before Sir Joseph Lister introduced the system of antiseptic surgery, bacteria were a most fertile source of danger in surgical operations by the decomposition and suppuration they set up in the wounds.

In this short paper it is impossible to describe the characteristics of any other pathogenic bacteria, but perhaps enough has been written to show the great danger to which we are exposed from attacks by an immense army of minute foes.

FOREST FORMATIONS

—M. J. SCHLEIDEN

IT is difficult to give the character of the various wood-formations in woods with even a small proportion of that vividness and reality which the landscape painter so readily attains by drawing, foliage, color, and effect of light. Nevertheless, the differences are striking enough to all who approach nature with open senses. Even the fir and pine woods exhibit essential differences in their features; the

former with straight stems arranged parallel to each other like columns, with the conical crowns of verticillate branches; the latter bearing on the gnarled, curved trunks, the lines of which cross in all directions in perspective, a flat umbel of foliage, a bearing which is most purely and nobly exhibited by the stone pine. These pine-woods, which extend over miles of country in the Mark of Brandenburg, are repeated in more luxuriant development in the "pine-barrens" of North America. Here, as there, loving a sandy soil, they extend in a broad band several hundred miles long, down to the coast of North Carolina, forming by their mass a very prominent feature in the physiognomy of the whole country.

Still more striking is the distinction between the particular formations of the leafy woods; the crowded arrangement of the social beeches, limes, or elms produces woods with dusky shades and a soil void of vegetation, while the proud oak, repressing the growth of all other trees in its immediate neighborhood, stands alone upon a soil pleasantly clothed with grass and herbs, or unites in small groups to form those wonderful woodland landscapes to which the immortal pencil of Ruysdæel so often introduces us.

Differently acts the massive lustre of the magnolia woods of the southern part of North America, from the elegant beauty of the African acacia groves, or the ghost-like transparency of the northern birch, and the whole tropical world unfolds a multiformity, the description of which would be an inexhaustible theme.

When the dense foliage hinders the action of the sun and the refreshing breeze, and thus retards the decomposition of the vegetable masses, where the ground, flat and without any declivity, allows the accumulation of water, and the more since the heaped-up bodies of dead plants continually increase the barriers to the efflux, and the humus formed greedily sucks up the moisture—there are formed the most extensive swamps. By the progressive action of the remains of vegetation the ground becomes elevated, and such spongy, semi-fluid masses often lie, at length, far above the level of the surrounding plain, the sun's heat never sufficing, even when storms remove the protecting roof, to dry up the marsh, or to restrain its increase. Such a swamp rises twelve feet above the surrounding plains in Virginia, between the towns of Suffolk and Walden, and is called by the inhabitants "the Great Dismal," giving origin to considerable rivers and supplying them with water. The North American cypress (*Cupressus disticha*) it is which with its delicate but dense foliage gives rise to the formation of these structures. It is the same tree which forms the terrible evil-renowned cypress swamps of Louisiana, on the banks of the Red River and the Mississippi. Gigantic trunks of unprecedented mightiness crowd together, interweaving their branches and spreading an obscure twilight in the brightest day. The soil consists merely of half-decayed blocks piled one upon another, alternating with a fathomless mud, in which the voracious alligators and snapping-turtles wallow, the sole lords of this hell, steaming up almost beneath the tropical sun

—thus in the height of summer; in the spring the thick, miry floods of the issuing streams impetuously overflow this malignant vegetation for many miles. Thus these cypress-swamps, of which Seatsfield has given us such a vivid picture, correspond in inland countries to the mangrove-woods which border the mouths of almost all the tropical rivers. Composed of a very few species of plants, among which the mangrove-tree is the most common, they are especially striking from the great number of strong roots springing out high up the stem, and bearing this aloft above the surface. The peculiar habitation of this plant is the *brackish water*, which consists, at the ebb, of the fresh water of the river, which is dislodged by the sea-water at the flood. The numerous roots often form a so thickly entangled mass that the interspaces may be stopped up by the falling leaves, collecting thus a soil for a new vegetation, beneath which, at different hours of the day, roll the waves of the river and the sea. But more frequently the roots merely operate to retard the flow of the water and to retain in their interlacements the vegetable and animal bodies driven down the river, which then decay here in contact with sea-water and its salts. In these regions the terrible sulphureted hydrogen gas is developed so abundantly, poisoning the atmosphere, that the natives who have lived in these abodes from their youth upward totter about as it were like spectres, while death almost inevitably snatches off the Europeans who enter there.

As the hill between mountain and level land, so between the wood-formation and the plain a link is

formed by the bush and the plains, displaying merely small, isolated groups of trees.

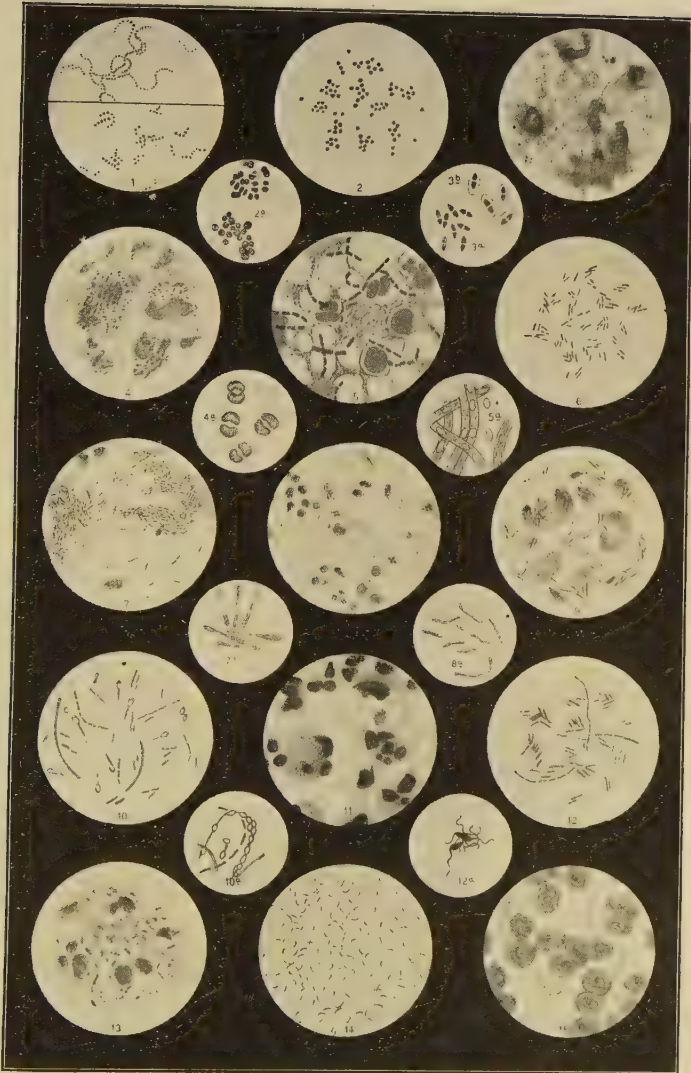
A portion of the so-called woods on the northern coast of Australia must be reckoned here, those which clothe the enormous tract extending southward into the interior from Raffles Bay and Essington. They exhibit a wholly peculiar physiognomy, which is repeated almost everywhere throughout this strange country. The trees and bushes have leathery leaves, the majority of them being covered with a white, resinous powder, which gives them the most monotonous, dismal, pallid look possible. The principal trees are species of *Eucalyptus*, *Acacia*, *Leptospermum* and *Melaleuca*. Many other plants, scarcely to be reckoned by the side of those named, live beneath the shelter of those lofty grayish stems, which stand far apart, and by their meagre, incessantly trembling foliage, remind us of the weeping willow. Handsome tufts of grass, with long, slender halm, grow throughout the whole extent of these bushes, and in them nestle the kangaroo, with the ring-dove and other birds. The sun's rays readily penetrate the narrow leaves, always waving on their long petioles, and produce an uncertain light mingled with fleeting shadows. The eye sees far up through the vault of twigs and leaves, and is arrested, not so much by the density of vegetation as by the continually changing glance of an uncertain mystic light.

Still lighter, still less representative of the closed conditions of woods, is the proper palm-form where the social kinds are grouped together. The real palm-groves on the northern border of Sahara and

on the shores of the Brazilian rivers more resemble open columned halls with perforated roofs; and on the dry soil of the elevated plains of Mexico the stems of the yucca, fourcroya, and other high-stemmed liliaceous plants are collected in a very peculiar way, affording neither shade from the sun nor shelter from the wind. To these approach the deformed masses of the Maguey-plants, with their broad, thick, rigid, dull-green leaves, sharply toothed on their borders, and their flowering stalks twenty feet high, rounded off into strange, fantastic, and impenetrable bush by cacti of manifold forms.

The impenetrable chaparrals in the extensive plains between the Nueces and the Rio Grande, formed of mosquito-shrubs, six to seven feet high, entwined with lianes; the palmetto-fields on the shores of the Sabine, Natchez, and other rivers of Texas, formed of rush and dwarf palms; the low acacia bush of Australia Felix, and lastly the wide jungles traversed by the elephants and tigers in the East Indies, and formed of bamboo and other lofty grasses, are all peculiarly characterized formations of bush, which often not attaining the height of a man, or but little exceeding it, do not all betray at the first glance the frequently insuperable obstacle they oppose to the intruder, and even after man has settled in the neighborhood can only be traversed by paths which the wild animals have made.

With a kind of feeling of disappointed expectation rides the traveler in the prairies of the West, anything but refreshing appears the monotonous surface uniformly overgrown with high grass, the line of the



Bacteria and Vegetable Germs

3, Pneumonia; 5, Anthrax; 7, Diphtheria; 8, Tuberculosis; 9, Leprosy;
10, Tetanus; 11, Influenza; 12, Typhus; 14, Cholera

horizon unbroken even by the smallest elevation. He rides and rides, but ever boundless space expands before his eyes, in the same uniformity, in the same calm simplicity.

Situated under similar latitudes and climatal conditions, the pampas of Buenos Ayres have a character similar to that of the North American prairies, only man by his influence on nature has here and there impressed a peculiar stamp. The thistle and artichoke, coming with the Europeans, have quickly made themselves masters of the free soil, and with incredible rapidity overspread districts of many square miles with their spiny vegetation, which has here developed in a luxuriance unknown in Europe. These thistle-wastes have become a terrible nuisance, themselves robbers, depriving better plants of the soil, inaccessible hiding-places for the great thievish, sanguinary cats, and the still more dangerous human bandits, the thorny weed of semi-civilization.

From the western border of northern France, through Belgium, North Germany, and Russia, almost to the eastern confines of Siberia, extends a broad plain rarely interrupted by low chains of hills, and just as rarely affording fitting soil for extensive growth of wood, which, on the whole, confines itself to the more favorable soil moistened by the vicinity of rivers. Along the southern border of this plain extends a chain of hills and mountains, now projecting forward like capes into the broad surface, now retreating into broad or narrow creeks, the coast of a sea formerly covering the whole plain. Over all this endless expanse has one single species of plant estab-

lished an almost exclusive predominance, the heath, which has lent its name to those tracts of land. Conditions similar to those which produce the distinction between the pine barrens and cypress swamps in North America are also active here to cause an essential difference. The great flatness of the ground, even geological conditions in many places, as where slight elevations of the land forming flat inclosed basins, prevent, in many situations, the free discharge of water, and the heath, backed by the special vegetation produced by the moisture, forms by the annual accumulation of vegetable matter, which in water only becomes to a certain degree carbonized or decomposed, those black masses of the remains of plants which as peat bear such an important part in the economy of the inhabitants. Thus, in various modes of distribution, alternate arid, dry sandy heaths with moist, spongy peat heaths or moors. On the margin of the latter, more rarely actually upon them, and on the heaths of Luneburg are often found splendid oaks, which, overshadowing one of those pleasant straw-thatched houses and thrown out by the background of the peculiar red tint of the glancing heather, produce a picturesque charm which would not have been expected here. With these great moors may be associated the peat moors of some of the higher mountain chains of the Brocken, the Röhn, and the Fichtel-Gebirge, and so on, and the so-called mosses of South Germany and Switzerland.

In another climate, in another zone of vegetation, exist similar conditions, stretching across the extreme north of Europe. As there the arid sandy heaths

alternate with the wet moors, so here in a more varied manner do the dry, waterless tracts, with the marshy grounds. But we are here in Wahlenberg's region of lichens and mosses. The arid situations are clothed, in expanses over which the eye can not reach, with dry, lead-gray lichens, among which the reindeer seeks his meagre sustenance, and in the half-fluid grounds, which will not bear the lightest footsteps, a luxuriant vegetation of mosses deceives us, in the distance, with the aspect of a smiling meadow. Here the incautious wanderer sinks into the water, which is rather concealed than displaced by the mosses, while on those lichen heaths, tundras, the Laplanders call them, in summer the glowing soil makes every step a torture.

The wood-formations of the South American catingas may be opposed to the northern leafy woods and, in like manner, the plains of the llanos of Venezuela to the Russian steppes. In the former, of which A. von Humboldt has given such a vivid sketch, the sleep of nature commences with summer, in the hot, dry season; the vegetation becomes dried up and falls to dust, leaving the ground bare; animal life, in the quadrupeds, flies from the dead land, while the crocodiles and boas burrow into the mud of the gradually exhausted rivers of the steppes, and with this become fixed, till the first torrent of rain, which conjures up a fresh, youthful vegetation on the barren soil and awakens them to life.

It is different in the steppes which stretch from southern Russia eastward through central Asia. I will only mention the strange salt-steppes, which in

summer often glitter like newly fallen snow, from the salt which effloresces from the soil and nourishes a wholly peculiar vegetation. Yet I can not refrain from attempting a brief description of the sparingly populated but still inhabited Tartarian steppes of Pontus. These do not uniformly present a level surface, being broken by the durrinas, low tracts of bush of blackthorns, hawthorns, roses and brambles. But the remaining part of the vegetation is also divided by the inhabitants of lesser Russia, according to its use for pasture, into two essentially distinct groups, the truwa, the turf, and the burian, the rough, branching plants which, on account of their woody stem, afford no sustenance to the herds of the steppes. The feather-grass* is the principal among the Gramineous plants. Directly after flowering, it expands its long, delicately feathered awns, not unlike marabout feathers, from the spike which rises high above the tuft of narrow, dry leaves. The older the steppe, the higher develops the woody root-stock above the soil, to the annoyance of the mower. Whoever travels but a few miles into the steppes soon hears the word burian. Against the burian inveighs the herdsman with his oxen and horses; over the burian laments the husbandman; the burian is the curse of the gardener and the hope of the cook. For in the soil of the steppe, which is peculiarly fertile for certain plants, which we call weeds, these shoot up to an incredible height, wherever cultivation has loosened the solid soil, which they avoid, and their

* Silk-plant, *Stipa pennata*.

peculiar use is that, dried up in the autumn, they furnish the only fuel of those regions. Above all, as in the pampas of Buenos Ayres, the thistles distinguish themselves, acquiring a size, a development, and ramification which is really marvelous. Often do they stand like little trees around the humble earth-hovels of the country people; on favorable soil, they often form extensive bush, even overtopping the horseman, who is as helpless in it as in a wood, since they intercept the sight and yet afford no trunk which might be climbed. Beside the thistle rises the wormwood, intermingled with the gigantic mullein or hightaper, the "steppe-light" of lesser Russia. Even the little milfoil grows several feet high and is not a little prized, since the inhabitants, from their poor provision, value it as the best material for fuel. But the most characteristic of all the plants of the burian is that which the Russians call "Perekatipole," the "Leaf in the Field," and the German colonists, almost more happily, the "Wind Witch." A poor thistle-plant, it divides its strength in the formation of numerous dry, slender shoots, which spread out on all sides and are entangled with one another. More bitter than wormwood, the cattle will not touch it even in times of the utmost famine. The domes which it forms upon the turf are often three feet high and sometimes ten to fifteen in circumference, arched over with naked, delicate thin branches. In the autumn the stem of the plant rots off, and the globe of branches dries up into a ball, light as a feather, which is then driven through the air by the autumnal winds over the steppe. Numbers

of such balls often fly at once over the plain with such rapidity that no horseman can catch them; now hopping with short, quick springs along the ground, now whirling in great circles round each other, rolling onward in a spirit-like dance over the turf, now, caught by an eddy, rising suddenly a hundred feet into the air. Often one wind witch hooks on to another, twenty more join company, and the whole gigantic yet airy mass rolls away before the piping east wind.

THE HIGH WOODS

—CHARLES KINGSLEY

MY first feeling on entering the high woods was helplessness, confusion, awe, all but terror. One is afraid at first to venture in fifty yards. Without a compass or the landmark of some opening to or from which he can look, a man must be lost in the first ten minutes, such a sameness is there in the infinite variety. That sameness and variety make it impossible to give any general sketch of a forest. Once inside "you can not see the woods for the trees." You can only wander on as far as you dare, letting each object impress itself on your mind as it may, and carrying away a confused recollection of innumerable perpendicular lines, all straining upward, in fierce competition, toward the light-food far above; and next on a green cloud, or rather mist, which hovers round your head, and rises, thickening and thickening to an unknown height. The upward lines are of every possible thickness, and of almost

every possible hue; what leaves they bear, being for the most part on the tips of the twigs, give a scattered, mist-like appearance to the under foliage. For the first moment, therefore, the forest seems more open than an English wood. But try to walk through it, and ten steps undeceive you. Around your knees are probably Mamures, with creeping stems and fan-shaped leaves, something like those of a young cocoanut palm. You try to brush among them, and are caught up instantly by a string or wire belonging to some other plant. You look up and round: and then you find that the air is full of wires—that you are hung up in a network of fine branches belonging to half a dozen sorts of young trees, and intertwined with as many different species of slender creepers. You thought at your first glance among the tree-stems that you were looking through open air; you find that you are looking through a labyrinth of wire-rigging, and must use the cutlass right and left at every five steps. You push on into a bed of strong sedge-like *Sclerias*, with cutting edges to their leaves. It is well for you if they are only three, and not six, feet high. In the midst of them you run against a horizontal stick, triangular, rounded, smooth, green. You take a glance along it right and left, and see no end to it either way, but gradually discover that it is the leaf-stalk of a young Cocorite palm. The leaf is five-and-twenty feet long, and springs from a huge ostrich plume, which is sprawling out of the ground and up above your head a few yards off. You cut the leaf-stalk through right and left, and walk on, to be stopped

suddenly (for you get so confused by the multitude of objects that you never see anything till you run against it) by a gray lichen-covered bar, as thick as your ankle. You follow it up with your eyes, and find it entwine itself with three or four other bars, and roll over with them in great knots and festoons and loops twenty feet high, and then go up with them into the green cloud over your head and vanish, as if a giant had thrown a ship's cables into the tree-tops. One of them, so grand that its form strikes even the negro and Indian, is a Liantasse. You see that at once by the form of its cable—six or eight inches across in one direction, and three or four in another, furbelowed all down the middle into regular knots, and looking like a chain cable between two flexible iron bars. At another of the loops, about as thick as your arm, your companion, if you have a forester with you, will spring joyfully. With a few blows of his cutlass he will sever it as high up as he can reach, and again below, some three feet down; and while you are wondering at this seemingly wanton destruction, he lifts the bar on high, throws his head back, and pours down his thirsty throat a pint or more of pure, cold water. This hidden treasure is, strange as it may seem, the ascending sap, or, rather, the ascending pure rain-water which has been taken up by the roots, and is hurrying aloft, to be elaborated into sap, and leaf, and flower, and fruit and fresh tissue for the stem up which it originally climbed, and therefore it is that the woodman cuts the water-vine through first at the top of the piece which he wants and not at the bottom;

for so rapid is the ascent of the sap that if he cut the stem below the water would have all fled upward before he could cut it off above. Meanwhile the old story of Jack and the Beanstalk comes into your mind. In such a forest was the old dame's hut, and up such a beanstalk Jack climbed to fight a giant, and a castle high above. Why not? What may not be up there? You look up into the green cloud, and long for a moment to be a monkey. There may be monkeys up there over your head—burly red Howler, or tiny, peevish Sapajou, peering at you, but you can not peer up at them. The monkeys and the parrots and the humming-birds and the flowers and all the beauty are upstairs—up above the green cloud. You are in "the empty nave of the cathedral," and "the service is being celebrated aloft in the blazing roof."

We will hope that as you look up you have not been careless enough to walk on, for if you have you will be tripped up at once; nor to put your hand out incautiously to rest it against a tree, or what not, for fear of sharp thorns, ants, and wasps' nests. If you are all safe, your next steps, probably, as you struggle through the bush between tree-trunks of every possible size, will bring you face to face with huge upright walls of seeming boards, whose rounded edges slope upward till, as your eye follows them, you find them enter an enormous stem, perhaps round, like one of the Norman pillars of Durham nave, and just as huge; perhaps fluted, like one of William of Wykeham's columns at Winchester. There is the stem, but where is the tree? Above the

green cloud. You struggle up to it between two of the board walls, but find it not so easy to reach. Between you and it are half a dozen tough strings which you had not noticed at first—the eye can not focus itself rapidly enough in this confusion of distances—which have to be cut through ere you can pass. Some of them are rooted in the ground, straight and tense; some of them dangle and wave in the wind at every height. What are they? Air-roots of wild pines, or of Matapolos, or of figs, or of Seguines, or of some other parasite? Probably; but you can not see. All you can see is, as you put your chin close against the trunk of the tree and look up, as if you were looking up against the side of a great ship set on end, that some sixty or eighty feet up in the green cloud arms as big as English forest-trees branch off, and that out of their forks a whole green garden of vegetation has tumbled down twenty or thirty feet, and half climbed up again. You scramble round the tree to find whence this aerial garden has sprung; you can not tell. The tree-trunk is smooth and free from climbers, and that mass of verdure may belong possibly to the very cables which you met ascending into the green cloud twenty or thirty yards back, or to that impenetrable tangle a dozen yards on, which has climbed a small tree, and then a taller one again, and then a taller still, till it has climbed out of sight, and possibly into the lower branches of the big tree. And what are their species? What are their families? Who knows? Not even the most experienced woodman or botanist can tell you the names of plants of which

he only sees the stems. The leaves, the flowers, the fruit, can only be examined by felling the tree; and not even always then, for sometimes the tree, when cut, refuses to fall, linked as it is by chains of liane to all the trees around. Even that wonderful water-vine which we cut through just now may be one of three or even four different plants.

Soon you will be struck by the variety of vegetation, and you will recollect what you have often heard, that social plants are rare in the tropic forests. Certainly they are rare in Trinidad, where the only instances of social trees are the Moras (which I have never seen growing wild) and the Moriche palms. In Europe a forest is usually made up of one dominant plant—of firs or of pines, of oaks or of beeches, of birch or of heather. Here no two plants seem alike. There are more species on an acre here than in all the New Forest, Savernake, or Sherwood. Stems rough, smooth, prickly, round, fluted, stilted, upright, sloping, branched, arched, jointed, opposite-leaved, alternate-leaved, leafless, or covered with leaves of every conceivable pattern, are jumbled together, till the eye and brain are tired of continually asking, "What next?" The stems are of every color, copper, pink, gray, green, brown, black, as if burnt, marbled with lichens, many of them silvery white, gleaming afar in the bush, furred with mosses and delicate creeping film-ferns, or laced with the air-roots of some parasite aloft. Up this stem scrambles a climbing Seguine with entire leaves; up the next, another quite different, with deeply cut leaves; up the next, the Ceriman spreads its huge

leaves latticed and forked again and again. So fast do they grow, that they have not time to fill up the spaces between their nerves, and are consequently full of oval holes; and so fast does its spadix of flowers expand, that (as indeed do some other Aroids) an actual genial heat, and fire of passion, which may be tested by the thermometer, or even by the hand, is given off during fructification. Beware of breaking it or the Seguines. They will probably give off an evil smell, and as probably a blistering milk. Look on at the next stem. Up it, and down again, a climbing fern, which is often seen in hot-houses, has tangled its finely cut fronds. Up the next a quite different fern is crawling, by pressing tightly to the rough bark its creeping root-stalks, furred like a hare's leg. Up the next, the prim little Griffeschatte plant has walked, by numberless clusters of small cat's claws which lay hold of the bark. And what is this delicious scent about the air? Vanille? Of course it is; and up that stem zigzags the green fleshy chain of the Vanille Orchis. The scented pod is far above, out of your reach, but not out of the reach of the next parrot, or monkey, or negro-hunter who winds the treasure. And the stems themselves—to what trees do they belong? It would be absurd for one to try to tell you who can not tell one-twentieth of them himself. Suffice it to say that over your head are perhaps a dozen kinds of admirable timber which might be turned to a hundred uses in Europe, were it possible to get them thither: your guide will point with pride to one column after another, straight as those of a cathedral, and sixty to eighty feet with-

out branch or knob. That, he will say, is Fiddlewood; that a Carap; that a cedar; that a Roble (oak); that, larger than all you have seen yet, a locust; that a Poui; that a Guatecare; that an Olivier—woods which, he will tell you, are all but incorruptible, defying weather and insects. He will show you, as curiosities, the smaller but intensely hard letter wood *lignum-vitæ*, and purple heart. He will pass by as useless weeds *Ceibas* and sandbox-trees, whose bulk appalls you. He will look up, with something like a malediction, at the Matapalos, which every fifty yards have seized on mighty trees, and are enjoying, I presume, every different stage of the strangling art, from the baby Matapalo, who has let down his first air-root along his victim's stem, to the old sinner whose dark crown of leaves is supported, eighty feet in air, on innumerable branching columns of every size, cross-clasped to each other by transverse bars. The giant tree on which his seed first fell has rotted away utterly, and he stands in its place, prospering in his wickedness, like certain folk whom David knew too well. Your guide walks on with a sneer, but he stops with a smile of satisfaction as he sees lying on the ground dark green glossy leaves, which are fading into a bright crimson, for overhead somewhere there must be a Balata, the king of the forest; and there, close by, is his stem—a madder-brown column, whose head may be a hundred and fifty feet or more aloft. The forester pats the sides of his favorite tree as a breeder might that of his favorite race-horse. He goes on to evince his affection, in the fashion of

the West Indians, by giving it a chop with his cutlass, but not in wantonness. He wishes to show you the hidden virtues of this (in his eyes) noblest of trees—how there issues out swiftly from the wound a flow of thick white milk, which will congeal, in an hour's time, into a gum intermediate in its properties between caoutchouc and gutta-percha. He talks of a time when the English gutta-percha market shall be supplied from the Balatas of the northern hills which can not be shipped away as timber. He tells you how the tree is a tree of a generous, virtuous, and elaborate race—"a tree of God, which is full of sap," as one said of old of such—and what could he say better, less or more? For it is a Sapota, cousin to the Sapodilla, and other excellent fruit-trees, itself most excellent even in its fruit-bearing power; for every five years it is covered with such a crop of delicious plums that the lazy negro thinks it worth his while to spend days of hard work, besides incurring the penalty of the law (for the trees are government property), in cutting it down for the sake of its fruit.

But this tree your guide will cut himself; so he leaves a significant mark on his new-found treasure and leads you on through the bush, hewing his way with light strokes right and left, so carelessly that you are inclined to beg him to hold his hand and not destroy in a moment things so beautiful, so curious—things which would be invaluable in an English hothouse.

And where are the famous orchids? They perch on every bough and stem; but they are not, with

three or four exceptions, in flower in the winter; and if they were, I know nothing about them—at least I know enough to know how little I know. Whosoever has read Darwin's *Fertilization of Orchids*, and finds in his own reason that the book is true, had best say nothing about the beautiful monsters till he has seen with his own eyes more than his master. And yet even the three or four that are in flower are worth going many a mile to see. In the hothouse they seem almost artificial from their strangeness; but to see them "natural," on natural boughs, gives a sense of their reality which no unnatural situation can give. Even to look up at them, as one rides by, and to guess what exquisite and fantastic forms may issue, in a few months or weeks, out of those fleshy, often unsightly, leaves, is a strange pleasure—a spur to the fancy which is surely wholesome, if we will but believe that all these things were invented by A Fancy, which desires to call out in us, by contemplating them, such small fancy as we possess; and to make us poets, each according to his power, by showing a world in which, if rightly looked at, all is poetry.

Look here at a fresh wonder. Away in front of us a smooth gray pillar glistens on high. You can see neither the top nor the bottom of it. But its color and its perfectly cylindrical shape tell you what it is—a glorious Palmiste; one of those queens of the forest which you saw standing in the fields, with its capital buried in the green cloud and its base buried in that bank of green velvet plumes, which you must skirt carefully round, for they are a prickly dwarf

palm, called here Black Roseau. Close to it rises another pillar, as straight and smooth, but one-fourth of the diameter—a giant's walking-cane. Its head, too, is in the green cloud. But near are two or three younger ones only forty or fifty feet high, and you see their delicate feather heads, and are told that they are Manacques; the slender nymphs which attend upon the forest queen, as beautiful, though not as grand, as she.

The land slopes down fast now. You are tramping through stiff mud, and those Roseaux are a sign of water. There is a stream or gully near; and now, for the first time, you can see clear sunshine through the stems, and see, too, something of the bank of foliage on the other side of the brook. You catch sight, it may be, of the head of a tree aloft, blazing with golden trumpet-flowers, which is a Pouï; and of another lower one covered with hoar-frost, perhaps a Croton; and of another, a giant covered with purple tassels: this is an Angelim. Another giant overtops even him. His dark, glossy leaves toss off sheets of silver light as they flicker in the breeze, for it blows hard aloft outside while you are in stifling calm. That is a Balata. And what is that on high—twenty or thirty square yards of rich crimson a hundred feet above the ground? The flowers may belong to the tree itself. It may be a mountain mangrove, which I have never seen in flower; but take the glasses and decide. No. The flowers belong to a liane. The "wonderful" Prince of Wales's feather has taken possession of the head of a huge Mombin, and tiled it all over with crimson combs,

which crawl out to the ends of its branches, and dangle twenty or thirty feet down, waving and leaping in the breeze. And over all blazes the cloudless blue.

You gaze astonished. Ten steps downward and the vision is gone. The green cloud has closed again over your head and you are stumbling in the darkness of the bush, half blinded by the sudden change from the blaze to the shade. Beware. "Take care of the Croc-chien!" shouts your companion; and you are aware of, not a foot from your face, a long, green, curved whip armed with pairs of barbs some four inches apart; and are aware also at the same moment that another has seized you by the arm, another by the knees, and that you must back out, unless you are willing to part with your clothes first and your flesh afterward. You back out, and find that you have walked into the tips—luckily only into the tips—of the fern-like fronds of a trailing and climbing palm such as you see in the Botanic Gardens. That came from the East, and furnishes the rattan canes. This furnishes the gri-gri canes, and is rather worse to meet, if possible, than the rattan. Your companion, while he helps you to pick the barbs out, calls the palm laughingly by another name, "Suelto-Ingles," and tells you the old story of the Spanish soldier at San Josef. You are near the water now, for here is a thicket of Balisiers. Push through, under their great plantain-like leaves—step down the muddy bank to that patch of gravel. See first, though, that it is not tenanted already by a deadly Mapepire, or rattlesnake,

which has not the grace, as his cousin in North America has, to use his rattle.

The brooklet, muddy with last night's rain, is dammed and bridged by winding roots, in shape like the jointed wooden snakes which we used to play with as children. They belong probably to a fig, whose trunk is somewhere up in the green cloud. Sit down on one, and look, around and aloft. From the soil to the sky, which peeps through here and there, the air is packed with green leaves of every imaginable hue and shape. Round our feet are Arums, with snow-white spadixes and hoods, one instance among many here of brilliant color developing itself in deep shade. But is the darkness of the forest actually as great as it seems? Or are our eyes, accustomed to the blaze outside, unable to expand rapidly enough, and so liable to mistake for darkness air really full of light reflected downward, again and again, at every angle, from the glossy surfaces of a million leaves? At least we may be excused; for a bat has made the same mistake, and flits past us at noonday. And there is another—no; as it turns, a blaze of metallic azure off the upper side of the wings proves this one to be no bat, but a Morpho—a moth as big as a bat. And what was that second larger flash of golden green, which dashed at the moth and back to yonder branch not ten feet off? A Jacamar—kingfisher, as they miscall her here, sitting, fearless of man, with the moth in her long beak. Her throat is snowy white, her under parts rich red brown. Her breast and all her upper plumage and long tail glitter with golden green.

There is light enough in this darkness, it seems. But now look again at the plants. Among the white flowered Arums are other Arums, stalked and spotted, of which beware; for they are the poisonous Seguine-diable, the dumb-cane, of which evil tales were told in the days of slavery. A few drops of its milk, put into the mouth of a refractory slave, or again into the food of a cruel master, could cause swelling, choking, and burning agony for many hours.

Over our heads bend the great arrow leaves and purple leaf-stalks of the Tantias; and mingled with them leaves often larger still: oval, glossy, bright, ribbed, reflecting from their under side a silver light. They belong to Arumas; and from their ribs are woven the Indian baskets and packs. Above these, again, the Balisiers bend their long leaves, eight or ten feet long apiece; and under the shade of the leaves their gay flower-spikes, like double rows of orange and black birds' beaks upside down. Above them, and among them, rise stiff, upright shrubs, with pairs of pointed leaves, a foot long some of them, pale green above, and yellow or fawn-colored beneath. You may see, by the three longitudinal nerves in each leaf, that they are Melastomas of different kinds—a sure token that you are in the tropics—a probable token that you are in tropical America.

And over them, and among them, what a strange variety of foliage. Look at the contrast between the Balisiers and that branch which has thrust itself among them, which you take for a dark, copper-

colored fern, so finely divided are its glossy leaves. What a contrast again, the huge feathery fronds of the Cocorite palms which stretch right away hither over our heads, twenty and thirty feet in length. And what is that spot of crimson flame hanging in the darkest spot of all from an under bough of that low, weeping tree? A flower head of the *Rosa del Monte*. And what that bright, straw-colored fox's brush above it, with a brown hood like that of an *Arum*, brush and hood nigh three feet long each? Look—for you require to look more than once, sometimes more than twice—here, up the stem of that Cocorite, or as much of it as you can see in the thicket. It is all jagged with the brown butts of its old fallen leaves; and among the butts perch broad-leaved ferns and fleshy orchids, and above them, just below the plume of mighty fronds, the yellow fox's brush, which is its spathe of flower.

What next? Above the Corcorites dangle, amid a dozen different kinds of leaves, festoons of a liane, or of two, for one has purple flowers, the other yellow—*Bignonias*, *Bauhinias*—what not? And through them a Carat palm has thrust its thin, bending stem and spread out its flat head of fan-shaped leaves twenty feet long each: while over it, I verily believe, hangs eighty feet aloft the head of the very tree upon whose roots we are sitting. For amid the green cloud you may see sprigs of leaf somewhat like that of a weeping willow; and there, probably, is the trunk to which they belong, or rather what will be a trunk at last. At present it is like a number of round edged boards of every size, set on end, and

slowly coalescing at their edges. There is a slit down the middle of the trunk, twenty or thirty feet long. You may see the green light of the forest shining through it. Yes, that is probably the fig; or, if not, then something else. For who am I, that I should know the hundredth part of the forms on which we look?

And above all you catch a glimpse of that crimson mass of *Norantea* which we admired just now; and, black as yew against the blue sky and white cloud, the plumes of one *Palmiste*, who has climbed toward the light, it may be for centuries, through the green cloud; and now, weary and yet triumphant, rests her dark head among the bright foliage of a *Ceiba*, and feeds unhindered on the sun.

There, take your tired eyes down again; and turn them right or left, where you will, to see the same scene, and yet never the same. New forms, new combinations; wealth of creative Genius—let us use the wise old word in its true sense—incomprehensible by the human intellect or the human eye, even as He is who made it all, whose garment, or rather whose speech, it is.

MILK-SAP PLANTS

—M. J. SCHLEIDEN

ALL the plants which count caoutchouc among their products belong to the torrid zone. A. von Humboldt, in his *Ideas of a Geography of Plants*, remarked that the plants yielding *milky* juices multiply as we approach the tropics. This *milky*

juice of plants it is which contains the peculiar elastic substance. The tropical heat seems to exert a distinct influence in its perfect formation, for it has been remarked that the same plants which under the equator yield abundance of caoutchouc contain instead, with us, even in hothouses, a substance which resembles the bird-lime obtained from our native mistletoe.

Who among my readers has not seen our indigenous wolf's-milk or spurge, the white milky juice of which popular superstition recommends as a remedy against warts? Who has not in youth at least become acquainted with the celandine, from the broken stalk and leaf of which a bright orange-colored juice runs out? Who has not observed that the lettuce, when it has run up to flower, ejects a milk-white fluid at the slightest touch? But the occurrence of milky juices in plants is not limited to these few. The vegetable world presents to us most useful as well as poisonous matters in this milky sap, and I will content myself at present with recalling to recollection opium, the dried milky juice of our large garden poppy.

A great number of plants, which principally belong to three great families, namely, the Spurges, the Apocynocæ, and the Nettle plants, are distinguished by a peculiar anatomical structure. In their bark, and also partly in their pith, we find a quantity of long, variously curved and branched tubes, which are not unlike the veins of animals. In these tubes we find a thick juice of the consistence of very rich milk, whence it is called milk-sap. Its color is usually milk-white, but yellow, red, and, very rarely,

blue milk-saps are met with, but more frequently still they are wholly colorless. Like animal milk, this juice consists of a colorless fluid and small globules. The composition displays the most varied constituents, and upon the variation of quantity and modes of mixture of these matters depend the abundant varieties of this juice. All contain more or less caoutchouc, which occurs in the form of little globules. These are prevented from coalescing by an albuminous substance, in the same way as are the butter globules in milk. Exactly like the cream (the butter) in milk, the caoutchouc globules rise to the surface of the milk-sap of plants when left to stand, here form a cream, and can not, any more than butter, be separated again into their distinct globules.

All those three great families which are distinguished by their abundance of milk-sap, although differing very widely botanically, exhibit some most remarkable agreements through the nature of their milk-sap.

The spurges or Euphorbiaceæ constitute the most important group in reference to the amount of caoutchouc contained. From the Port of Para in South America, from Guiana, and the neighboring states, an incredible quantity of India-rubber is shipped for Europe, and this is principally obtained from a large tree growing in those regions, called the *Siphonia elastica*. That beautiful tree, the *Siphonia*, is about sixty feet high, and has a smooth brownish-gray bark, in which the Indians make long and deep incisions down to the wood, from whence the white juice then abundantly flows forth.

Many other plants of this group contain caoutchouc, but from none is it so easy to obtain in large quantity. Though the sap of *Siphonia* is at least harmless, though the juice of the *Tabayba dolce* (*Euphorbia balsamifera*) is even similar to sweet milk and, thickened into a jelly, eaten as a delicacy by the inhabitants of the Canary Islands, as Leopold von Buch relates in his interesting description of the Canaries; yet most of the plants of this group are to be counted among the suspicious, or even most actively poisonous, on account of this very juice. And yet, strangely enough, they also furnish a most wholesome food, which we have scarcely anything to compare with. Throughout all the hotter part of America the culture of the mandioc-root (*Jatropha Manihot*) is one of the most important branches of husbandry. The native savages and the Europeans, the black slave and free man of color alike substitute for our white bread and rice the tapioca and the Mandioca farinha, or Cassava-meal, and the cakes prepared from it (*pan de tierra caliente* of the Mexicans). The sweet yucca (*Yuca dulce*), which is the name applied there to the mandioc plant, must be distinguished from the sour or bitter kind (*Yuca amara*). The former, which is therefore cultivated with great care, may be eaten at once without danger; while the latter, eaten fresh, is an active poison. They serve the uncivilized son of the South American tropics for food.

The sated savage saunters round to seek a new sleeping-place, but woe to him! inadvertently he has prepared his couch beneath the dreadful manchineel

(*Hippomane Mancinella*), and in a sudden shower the rain drips from its leaves upon him. In frightful pain he wakes up, covered with blisters and ulcers, and if he escapes with life, he is at least the richer of a fearful experience of the poisonous properties of the *Euphorbiaceæ*. But this will seldom happen to a native; the manchineel is avoided in America with the same mysterious and almost superstitious awe as the fabulous poison-tree in Java. Happily, the trumpet-tree (*Bignonia leucoxylon*), the sap of which is the surest antidote against the manchineel, usually rears its beautiful purple blossoms close at hand, the constant companion of that dangerous *Euphorbiacean*.

The planter of the Cape strews over pieces of flesh the pounded fruit of a plant that grows there (*Hyænanche globosa*), and lays them as an infallible poison for the hyena. The wild inhabitants of southern Africa, according to Bruce, poison their arrows with a spurge (*Euphorbia caput Medusæ*). Virey states that the Ethiopians make a similar application of others (*Euphorbia heptagona*, *Euphorbia virosa*, *Euphorbia cereiformis*), while the savages of the most southern part of America use the sap of a third (*Euphorbia cotinifolia*). Nay, even our seemingly so innocent box, which also belongs to this family, is so injurious that in places in Persia, where it much abounds, no camels can be kept, because it is impossible to prevent their feeding on this plant, which is deadly to them. I can not take leave of this family without mentioning a remarkable phenomenon, reported to us by Martius, in that work so full of infor-

mation, his *Travels Through Brazil*. A spurge grows there (*Euphorbia phosphorea*), the milk of which, when it flows forth from the stem in the dark, hot summer nights, emits a bright phosphoric light.

While the family just alluded to, the blossoms being generally insignificant, attract the attention of our horticulturists almost solely through their strange forms, which, in some of them, approach to those of the cactus plants, the family of the Apocynaceæ is, on the contrary, a rich ornament of our gardens and hothouses, on account of the wonderful beauty of its blossoms, and is often still more attractive from the remarkable structure of the flowers, and the aberrant, also cactus-like form of the plant itself. What lover of flowers knows not the splendid blossom of the species of *Carissa*, *Allamanda*, *Thevetia*, *Cerbera*, *Plumieria*, *Vinca*, *Nervium*, and *Gelsemium*; the strange stalk and toad-colored, ill-smelling flowers of the *Stapelia*? But this family is not less interesting in other respects. The best caoutchouc at present known, that from Pulo Penang, comes from a plant of this family (*Cynanchum ovalifolium*). Also that from Sumatra (*Urceola elastica*), from Madagascar (*Vahea gummifera*), a part of the Brazilian *Colophora utilis* and *Hancornia speciosa*, and the East Indian *Willughbeia edulis* are obtained from plants which belong to the group of Apocynaceæ.

Most strangely, this family also, as well as the following and last, exhibits the peculiar phenomenon which was described in the first-named, the Euphorbiaceæ, namely, that the milk-sap is in some species rich in India-rubber, in others it is tempered

into a clear, agreeably smelling and wholesome milk, while in certain others, on the contrary, this fluid grows, step by step, through successively increasing quantity of noxious matter to a most dreadful poison. In the forests of British Guiana grows a tree which the natives call Hya-Hya (*Tabernæmontana utilis*). Its bark and pith are so rich in milk that an only moderate-sized stem, which Arnott and his companions felled on the bank of a large forest brook, in the course of an hour colored the water quite white and milky. This milk is perfectly harmless, of a pleasant flavor, and is taken by the savages as a refreshing drink. Still more pleasant must be the taste of the milk of the Ceylon cow-tree, the Kiriaghuma (*Gymneura lactiferum*), which, according to Burmann's narrative, the Cingalese use exactly as we do milk.

Dreadful, on the contrary, is the action of the terrible wourali poison, which the inhabitants of the banks of the Orinoco concoct with mystic conjurations, the chief ingredients of which are furnished by the juice of a plant belonging here (*Echites suberecta*) and the bark of another, likewise an Apocynaceous tree, *Strychnos guianensis* and *Strychnos toxifera*. The North Americans also use an Apocynaceous plant (*Gonolobium macrophyllum*) to poison their arrows; and Mungo Park related the like of the Mandingoes of the Niger (according to him it is a species of *Echites*).

Many allied plants are among the most active poisons (*Cerbera Thevetia* and *Cerbera Ahovai*), and the seeds of this group, in particular, are almost more remarkable for their deadliness than those of the

foregoing, for two of the most violent vegetable poisons, strychnine and brucine, occur in them. Some of our most active medicinal substances are especially known on this account; for instance, the St. Ignatius's beans (*Ignatia amara* from Manila), and the *Nux vomica* (*Strychnos nux Vomica*), distributed throughout the tropics.

It would not be difficult to make some of the more important characters of the two families I have mentioned so clear, even to a person unacquainted with botany, that he would be enabled readily to distinguish any plant belonging to them. Very different is it with the following, the last group, the Jussieuan family of nettle-plants, or *Urticaceæ*. The plants belonging to this vary in the most striking manner in their external forms, from the smallest, most insignificant weeds, like our common pellitory of the wall and our nettles, to vast and stately trees like the bread-fruits (*Artocarpus integrifolia* and *incisa*), which, with their wide-stretched branches and broad, beautifully formed leaves, overshadow the huts of the South Sea Islander, who lives upon their savory fruit. As in the family of the spurges, only some few plants bestow in their seed a pleasant nut-like kernel (as *Aleurites triloba* in the Moluccas, *Conceveiba guianensis* in South America); as in the *Apocynaceous* group, several trees afford cooling, juicy, and therefore highly valued fruits to the inhabitants of hot regions (*Carissa Carandas* in the East Indies, *Carissa edulis* in Arabia, etc.), so the family of the *Urticaceæ* includes the strangest multiplicity of fructifications. The little oil grains of the hemp, the green grape-like

bunches which gracefully adorn the slender twining hop, the aromatic mulberry, the sweet fig, the useful bread-fruit, all those so various forms belong to one group of plants, and the botanist traces in all the same fundamental structure, however incongruous these manifold shapes may appear to the eye of the uninitiated. One peculiarity alone extends without exception throughout all the species of this large order, namely, the presence of fine but strong bass-fibres in the bark. The German name for muslin, Nessel-tuch (nettle-cloth), denotes the source from whence the fibre of which it is made was originally obtained (*Urtica cannabina*), and the skilful industry of the gentle Tahitan prepares the most delicate stuff, without spinning-wheel or loom, from the fine white bass of the auté of paper-mulberry (*Broussonetia papyrifera*).

An elegant tree, allied to the last, the Holquahuitl of the Mexicans, or Ule di Papantla of the Spaniards (*Castilloa elastica* Deppe), furnishes the caoutchouc of New Spain, and the inconceivable quantities of this substance which are brought to our ports from the East Indies are collected in great part from the venerable fig-trees in which that Asiatic tropical world is so rich. On a trunk of giant girth, but seldom more than fifteen feet high, rests the enormous crown of the banyan, or holy fig (*Ficus religiosa*); the branches often run a hundred feet horizontally out from the trunk, sending down to the ground, at various intervals, long straight roots, which quickly penetrate and take firm hold, thus becoming props to the long branches. These won-

derful trees, each one resembling a small wood, are dedicated to the god Fo, and the helpless, lazy Bonze builds his hut, not unlike a bird-cage, in its branches, in which he passes the day, sometimes asleep, sometimes dreaming in contemplative indolence in the pleasant cool shade. These great fig-trees (*Ficus religiosa*, *indica*, *benjaminea*, *elastica*) have sweet fruits, and their milk-sap contains the interesting caoutchouc. Some of these plants also yield a harmless juice. By far the most remarkable in this respect is the Palo de Vacca or Arbol de Leche, the cow-tree of South America (*Galactodendron utile*), which was first made known to us by Alexander von Humboldt. When a tolerably large incision is made into the trunk of this tree, a white, oily, fragrant, and sweet fluid, very similar to animal milk, flows out in sufficient quantity to refresh and satisfy the hunger of several persons.

A striking contrast to this is afforded by the properties of other nettle-plants. One is tempted to call them the serpents of the vegetable kingdom; and the parallel is not difficult to carry out. The similarity between the instruments with which both produce and poison their wounds is very remarkable. The snakes have in the front of the upper jaw two long, thin, somewhat curved teeth, which are perforated lengthwise by a minute canal, which opens in front at the sharp point. These teeth are not fixed firmly in the jaw like the others, but movable, like, but in a less degree, the claws of a cat. Beneath each tooth, in a cavity in the jaw, lies a little gland, in which the poison is prepared, and the excretory duct

of this gland runs through the canal in the tooth, and opens at its apex. When the animal bites, the resistance of the bitten body pushes back the tooth, so that it presses upon the gland, which squeezes out of it the deadly fluid into the wound. If we examine, now, the hairs on the leaf of the nettle, we find a wonderful agreement. The stinging hair consists of a single cell, terminating above in a little knob. Below, it expands into a small sac, which contains the irritating juice.

The slightest touch breaks off the brittle point with the little knob, the canal of the hair is thus opened, and it penetrates any soft substance; in consequence of the pressure which the resistance to its entry exerts upon the sac, a portion of the poisonous juice is ejected out into the wound. The poisons of our native nettles and snakes are not of much consequence, but the nearer we approach the tropics, the more frequent and more deadly they both become. Where the glowing Indian sun ripens the poison of the fearful spectacle snake, there grow the most dangerous nettles.

Every one among us has felt the slight but irritating sting of the nettle which it produces by its slender poisonous hair, but we have no notion of the torture which its near allies (*Urtica stimulaus*, *Urtica crenulata*) produce in the East Indies. A gentle touch suffices to cause the arm to swell up with the most frightful pain, and the suffering lasts for weeks; nay, a species growing in Timor (*Urlica urentissima*) is called by the natives Daoun Setan (devil's leaf), because the pain lasts for years, and often even

death can only be avoided by the amputation of the injured limb.

We do, indeed, find many violent poisons in this family, and even some species of fig are included among the most dangerous plants (*Ficus toxicaria*), but it is not worth while to linger among those of lesser importance. The tales recounted of the Upas and the Poison-valley mingle almost like a dark and gloomy legend in our knowledge of the East Indian islands.

In the Sixteenth Century stories circulated about the macassar poison-tree of the Celebes; and physicians and naturalists came gradually to tell of the action of the poison, the descriptions of which had become so terrible that if the smallest quantity entered the blood, not only immediate death resulted, but its action was so fearfully destructive that within half an hour afterward the flesh fell from the bones. From Rumph we learned that the poison-tree is also met with in Sumatra, Borneo, and Bali, as well as in Celebes. But the Dutch surgeon, Försch, first spread the wild tales of the poison-tree of Java about the end of the Eighteenth Century.

Two very different trees grow in those little visited primeval forests of Java. All the paths leading to them are closed and watched, like those leading to the gates of the Holy of Holies. With fire and axe must the road be made through the impenetrably interwoven mass of lianes, the paullinias, with their clusters of great scarlet blossoms several feet long, the cissi or wild vines, on the widespread creeping roots of which thrives the gigantic flower of the Raf-

flesia Arnoldi. Palms, with spines and thorns, rush-like plants with cutting leaves, wounding like knives, warn the intruder back by their attacks, and in every part of the thicket threaten the fearful nettles formerly mentioned. Great black ants, whose painful bite tortures the wanderer, and countless swarms of tormenting insects pursue him. Are these obstacles overcome? Yet follow the dense bundles of bamboo stems, as thick as a man's arm, and often fifty feet high, the firm glassy bark of which repels even the axe. At last the way is opened and the majestic aisles of the true primeval forest now display themselves. Gigantic trunks of the bread-fruit, of the iron-like teak (*Tectona grandis*), of Leguminosæ, with their beautiful blossoms, of Barringtonias, figs, and bays, form the columns which support the massive green vault. From branch to branch leap lively troops of apes, provoking the wanderer by throwing fruit upon him. From a moss-clad rock the melancholy orang-outang raises himself gravely on his staff, and wanders into deeper thickets. All is full of animal life; a strong contrast to the desert and silent character of many of the primeval forests of America. Here a twining, climbing shrub, with a trunk as thick as one's arm, coils round the columns of the dome, overpassing the loftiest trees, often quite simple and unbranched for a length of a hundred feet from the root, but curved and winding in the most varied forms. The large, shining green leaves alternate with the long and stout tendrils with which it takes firm hold, and greenish-white heads of pleasant smelling flowers hang pendent from it. This plant,

belonging to the Apocynaceæ, is the Tjettek of the natives (Strychnos Tieute), from the roots of which the dreadful Upas Radia, or Sovereign Poison, is concocted. A slight wound from a weapon poisoned with this—a little arrow made of hard wood, and shot from the blow-tube, as by the South Americans—makes the tiger tremble, stand motionless a minute, then fall as though seized with vertigo, and die in brief but violent convulsions. The shrub itself is harmless, and he whose skin may have been touched with its juice need fear no consequences. As we go forward, we meet with a beautiful slender stem, which overtops the neighboring plants. Perfectly cylindrical, it rises sixty or eighty feet, smooth and without a branch, and bears an elegant hemispherical crown, which proudly looks down on the more humble growths around, and the many climbers struggling up its stem. Woe to him who heedlessly should touch the milk-sap that flows abundantly from its easily wounded bark. Large blisters, painful ulcers, like those produced by our poisonous sumach, only more dangerous, are the inevitable consequences. This is the Antiar of the Javanese, the Pohon Upas (signifying poison-tree) of the Malays, the Ipo of Celebes and the Philippines (*Antiaris toxicaria*).

NUTS.—GRANT ALLEN

ON the wooded slope where the park shelves slowly toward the Bourne Brook, the ground to-day (October) is thickly strewn in many places with the sharp, prickly husks and small, barren,

angular nutlets of the beautiful Spanish chestnuts. They are not truly indigenous to Britain, these noble spreading forest trees, though they have been planted so long in our pleasure grounds and lawns that we have got to look upon them almost as naturalized British subjects; and the climate, though it suits the leaves and wood well enough, is not sufficiently kindly to ripen the fruits in due season; they are almost always mere empty, shriveled shells here in England, so that we have to import seed for sowing from the mountain regions of Southern Europe. There we have all seen them growing in their own wild luxuriance on the lower escarpments of the Alps or the Apennines, and bringing forth fertile nuts sufficient to feed half the teeming population of the Lombard plain in seasons of scarcity. Side by side with them in the park here, the boys are impartially shying sticks at the very similar, though wholly unrelated, clusters of the common horse-chestnuts, which, in spite of their close external likeness, belong in reality to a totally different and much more restricted family. The true chestnut is a catkin bearer, a near relation of the English oak, as one might almost guess at sight from its foliage and habit; the horse-chestnut is a member of a tribe unrepresented in our native English flora, but not very unlike the maples and sycamores in its principal characters. It is interesting to note how in the case of these two wholly different and originally dissimilar trees similarity of circumstances has at last produced such great similarity of adaptive peculiarities.

The key to this strange resemblance between the

chestnut and the horse-chestnut is to be found in the fact that they are both *nuts*—they have survived in the struggle for existence by adopting for their seed-vessels the exactly opposite tactics from those adopted by the true fruits. A fruit, as we have often seen, is a seed-vessel which lays itself out, by all the allurements of bright color, sweet scent, sugary juices, and nutritive properties, to attract animals who will aid it by swallowing it, and so eventually dispersing its seeds. But a nut is a seed-vessel which, on the contrary, being richly supplied with starches and oils for the supply of the young plantlet, would be injured and diverted from its real intent and purport if it were to be eaten and digested by any animal. Accordingly, nuts have concentrated all their efforts upon repelling rather than attracting the attention of animals; or, to put it in a more strictly physical way, those nuts which have happened to be least attractive in color and most protected by hairs, spines, prickles, or bitter juices have best succeeded in escaping the attacks of animals, and so have prospered best in the struggle for existence. Thus, to drop into metaphor once more, while the fruits want to be eaten, the nut, on the contrary, wants to escape.

We may take the chestnut as a very good example of the general result which the necessity for protection usually produces in these peculiar seed-vessels. While it still grows on the tree the entire fruit is green and unobtrusive, hardly noticeable at a little distance among the heavy foliage which covers it on every side. Compare this shrinking and

secretive habit with the brilliancy and vividness of oranges and mangoes, or even with our own bright-colored northern rose-hips, and haws, and mountain ashes, and holly-berries. Again, instead of being smooth skinned and soft, like these bird-enticing fruits, the outer rind of the chestnut is rough and repellent with serried prickles, which rudely wound the tender nose of the too inquisitive squirrel, or even the feathery cheeks of the more protected nut-hatch. Once more, when the separate nuts inside have fallen out upon the ground, they are no longer green like the foliage upon the tree, but light brown or "chestnut," like the dead leaves and withered bracken into whose midst they have gently fallen. Chestnuts themselves are apparently sufficiently protected by these devices of color and prickliness; they do not seem further to require the special nut-like covering of a hard and woody shell; but the filbert, which suffers far more from the depredations of dormice, squirrels, nut-hatches, and other birds or mammals, has not only incased itself without in a green husk covered by sharp and annoying little hairs, but has also acquired a very solid and difficult shell, which often succeeds in baffling even the keen teeth or beaks of its persistent and aggressive animal foes.

Indeed, even among British nuts, one may trace a regular gradation (not, of course, genealogical) from the softest and least protected to the hardest and most defensive kinds. The acorn, produced in vast numbers by a very large and long-lived tree, the oak, has hardly any need of a strong outer coat

of armor, especially as its kernel is rather bitter and far from attractive to most animals, though it still feeds a considerable legion of hoarding squirrels, and must once have been munched in immense quantities by the native wild boars, or their mediæval successors, the half-tamed forest swine. In the beech, the shell of the actual nut itself is merely leathery; but the outer coat or involucre is sprinkled over with distinctly protective prickles. (It is worth while to note in passing that the beechnuts or mast rarely contain a kernel in Britain—in other words, they are almost always sterile; whereas in other countries where the beeches are more sturdy, the nuts are usually fertile; and this fact may be put side by side with the correlative fact that the beech is a decadent tree in England, where it was once dominant, but is now rapidly dying out before our very eyes, at least in its indigenous form.) In the lime, the very small nut has a decided shell, while its globular shape also makes it difficult for quadrupeds to open with their paws and teeth. Finally, in the hazel, the filbert has a very hard integument indeed, and a disagreeable, husky covering of smarting hairs.

Our own English nuts are only exposed to the attacks of extremely small and comparatively harmless mammals, or of inconsiderable native birds; and, therefore, their defensive tactics have never been carried any further than in the case of the hedgerow filbert. But in southern climates, and especially in the tropics, nuts are exposed to far larger and more dangerous forestine foes, like the monkeys and parrots, against whose teeth or bills, as we all

know, even the solid shell of the Barcelona cob is absolutely no protection. Hence, under these circumstances, only the very hardest or most disagreeable nuts have been able to survive and to grow up in due time into flourishing nut-trees. Sometimes, as in the walnut, the chief protection is afforded by a nauseous outer rind—a system which reaches its climax in the South American cashews, whose pungent juice blisters the skin like a cantharides plaster; sometimes, as in the cocoanut, it is afforded by great thickness and hardness of shell, which sets at naught the most persistent endeavors of the hungry aggressor. In the Brazil nut, a number of sharp, angular nuts are crowded together inside a large and hard outside shell, so that even after the monkey has managed to crack the big outer nut, he has still to open all the inside nuts one by one in detail. It is worth while to notice, too, that an exactly similar modification is undergone in the tropics by the stones of stone-fruits; which are really nuts in disguise, covered only by a soft, sweet pulp that entices animals to aid in dispersing them, by dropping the hard seed on to the ground in favorable spots for its growth. In temperate climates the stones are only hard enough to defy squirrels and birds: in tropical countries they are hard enough to defy monkeys and parrots. Compare, for example, the English sloe or birdcherry with the peach-stone, and the English haw with the mango or vegetable ivory. This last nut is one of the oddest in the whole range of nature, for it is here the actual kernel itself that grows so hard and horny. Yet even the vegetable ivory,

which consists really of very solid starchy cells, softens and yields up its material to the growing plant as soon as the embryo it incloses begins to sprout under the influence of warmth and moisture.

THE CACTUS TRIBE

—M. J. SCHLEIDEN

LET us leave the forest of Guiana, the last mat-roof of the Guaranese between the trunks of the Mauritius palm, and enter the pampas of Venezuela, of which Humboldt has sketched such a clever and vivid picture. No smiling verdure clothes the glowing rock-soil here; here and there in its crevices the *Melocactus* displays its round balls, "horrid" with threatening thorns. Ascend we thence the Andes; instead of tender grass, the earth is covered with pale, gray-green globes of spiny *Mamillarias*, while, intermingled, rises the solemn and mournful old-man cactus, with its venerable-looking long gray hair. Borne on the wings of fancy further north, we descend into the plains of Mexico, where the gigantic fragments of the city of the Aztecs, a product of a solitary era of civilization long lost to history, display themselves; the landscape spreads out before us as the bare and naked *Tierra caliente*, parched by the glowing sun; of a dull green hue, without a branch or leaf, the angled-columns of the torch-thistles rise twenty or thirty feet high, hemmed in with an impenetrable thicket of irritably pricking Indian figs, while round about appear the strangest, ugliest forms, in the groups of the *Echinocacti* and

little Cerei, between which creeps snake-like, or as some great poisonous reptile, the long, dry stem of the great flowered cactus (*Cereus nymphaeoides*). In short, one family accompanies us through all our wanderings, that of the cactus plants, which seems in all its wondrous forms to withdraw itself entirely from the principle of beauty, and yet at the same time presses forward so strikingly, so determinately marking the peculiar character of the landscape, that we are compelled to turn our attention to it. And in truth, a group which appears to retreat so far from all the laws of other plants deserves our interest in a very high degree.

Everything about these plants is wonderful. With the exception of the genus *Peireskia*, no plant of the order possesses leaves. Those parts of *Cactus alatus*, and the Indian fig, which are commonly called leaves, are nothing but flattened expansions of the stem. On the other hand, they are all distinguished by an extraordinarily fleshy stem, which, clothed by a grayish-green, leathery cuticle, and beset, in the places where leaves are situated in regular plants, with various tufts of hair, spines, and points, gives by its very varied degrees of development the varied character of the plants. The torch-thistles rise in form of nine-angled or often round columns to a height of thirty or forty feet, mostly branchless, but sometimes ramifying in the strangest ways, and looking like candelabra; the Indian figs are more humble; their oval, flat branches, arranged upon one another on all sides, produce special forms. The lowest and thickest torch-thistles connect themselves

with hedgehog and melon-cacti, with their projecting ribs, and thus lead us to the almost perfectly globular Mamillarias, which are covered very regularly with fleshy warts of various heights. Finally, there are forms in which the growth in the longitudinal direction prevails, which with long, thin, often whip-like stems, like those of the serpent-cactus, hang down from the trees upon which they live as parasites.

Few families have so limited a range of distribution upon the globe. All the species of cactus, perhaps without a single exception, are indigenous in America, between the parallels of 40° S. lat. and 40° N. lat. But some of them were so rapidly distributed through the Old World directly after the discovery of America, that they may almost be looked upon as fully naturalized there. Almost all delight in a dry situation, exposed to the burning rays of the sun, which contrasts strangely with their fleshy tissue, tumid with watery and not unpleasantly flavored with acid juice. This peculiarity gives them inestimable value to the fainting traveler, and Bernardin de St. Pierre has aptly called them the "Springs of the Desert." The wild ass of the llanos, too, knows well how to avail himself of these plants. In the dry season, when all animal life flees from the glowing pampas, when cayman and boa sink into death-like sleep in the dried-up mud, the wild ass alone, traversing the steppe, knows how to guard against thirst; cautiously stripping off the dangerous spines of the Melocactus with his hoof, and then in safety sucking the cooling vegetable juice. In vertical ex-

tension, the cacti are not confined within such narrow limits, and they stretch from the lowest tracts along the coast, through the vast plains, up to the highest ridges of the Andes chain. On the shore of Lake Titicaca, 12,700 feet above the level of the sea, are seen the tall-stemmed *Peireskias* with their splendid deep brown-red blossoms, and on the plateaus of southern Peru, near the limit of vegetation, therefore about 14,000 feet high, the wanderer is surprised by peculiar shapes of a yellowish-red color, which at a distance look like reposing savages, but which a closer inspection reveals to be shapeless heaps of low cacti, closely beset with yellowish-red spines.

What Nature has withheld, however, in external aspect, she has, in most, richly replaced in the magnificent blossom. We are astonished to find the deformed gray-green mass of the *Mamillaria* decked with the most beautiful purple-red flowers. Strange is the contrast between the wretched and gloomy aspect of the naked, dry stem of the large-flowered torch-thistle (*Cereus grandiflorus*), and its large, splendid, Isabel-colored,* vanilla-scented, flowers, which, unfolding under cover of the silent night, beam like suns, and in the wonderful sporting of their stamens, seem almost to strive toward a higher—an animal life.

But it is not the beauty of the blossom alone which

* Isabel color is a pale yellow, or buff, the shade of old linen, and received its name from Isabel of Austria, daughter of Philip II of Spain, who at the siege of Ostende, made the singular vow not to change her linen until that town fell into her hands. The siege lasted over three years.—E. S.

gladdens us, not the refreshing sap alone that revives the languishing traveler. The economic uses are also manifold. Almost all the cacti bear edible fruit, and a portion of them are among the most delightful refreshments of the hot zones which ripen them. Almost all the *Opuntias*, known by the name of Indian figs, furnish, in the West Indies and Mexico, a favorite dessert fruit, and even the little rose-red berries of the *Mamillarias*, which with us are tasteless, have, beneath the tropics, a pleasant, acidulated, sweet juice. We may say, in general terms, that their fruit is a nobler form of our native gooseberry and currant, to which also they are the nearest allies in a botanical point of view. Succulent as is the stem of most of the cacti, yet, in the course of time, they perfect in it a wood as firm as it is light. This is especially the case in the tall columnar species of *cereus*, the old dead stems of which, after the decay of the gray-green rind, remain erect, their white wood standing ghost-like among the living stems, till a benighted traveler seizes it in that scantily wooded region, to make a fire to protect him from the mosquitoes, to bake his maize-cake, or burns it as a torch to light up the dark tropical night. It is from the last use that they have obtained the name of torch-thistles. These stems, on account of their lightness, are carried up on mules to the heights of the Cordilleras, to serve as beams, posts, and door-sills in the houses; as, for instance, in the mayoral of Antisana, perhaps the highest inhabited spot in the world (12,604 feet). Just as their allies, the gooseberry bushes, are used by our country people to form hedges to

their gardens, are the *Opuntias* in Mexico, on the west coast of South America and in the southern part of Europe, and with greater success in the Canaries; their firm, shapeless branches soon interweave themselves into an impenetrable barrier, opposing, by their dreadful spines, an insuperable obstacle to the intruder. Lastly, the medicine-chest does not go away empty, for the physicians of America make abundant use of the acid juice for fomentations in inflammations, not to mention some other prescriptions.

In the same way that grass and clover are not immediately valuable to man, but serve as food for useful animals, so it is with a number of cacti, which support an insect of extraordinary importance. This is the cochineal insect (*Coccus Cacti*), a little, very insignificant creature, externally just like the little, white, cottony parasite, which is so often found upon the plants in our hothouses, and yet, through the invaluable coloring matter it contains, so infinitely different from it.

While the ugly form, the splendor of the blossom, and the manifold uses of the cactus plants attract general interest in a high degree, they are not less interesting, in a narrower sphere, to the botanist. Zoologists have at all times found in the examination of monstrosities and aberrant forms rich material toward the clearing and expanding of their knowledge of the regularly developing organism. It is to be expected, therefore, that similar conditions will have similar value in the vegetable world; and what family could be better selected for this purpose than the

Cactaceæ, which seems to be but a natural museum of monstrosities, where the forms are, in some cases, so abnormal that no other name could be thought of for one species but that of the deformed cactus (*Cereus monstrosus*) ?

It is believed that from the vast amount of watery juice in the cactus tribe, joined to the fact that most of them, and exactly those richest in sap, vegetate on dry sand, almost wholly devoid of vegetable mould, where they are besides exposed often three-fourths of the year to the parching sunbeams of an eternally serene sky; from this combination of circumstances, even, it is thought that we may the more safely conclude that these plants draw their nourishment from the air, since in our own hothouses also it has been observed that the branches of cactus stems cut off and left forgotten in a corner without further care, far from dying, have frequently grown on and made shoots three feet long or more. De Candolle first found the right path when he weighed such cactus shoots which had grown without soil, and found that the plant, though larger, was always lighter, therefore, instead of abstracting anything from the atmosphere, must rather have given up something to it. All the growth takes place, in such cases, at the expense of the nutritive matter previously accumulated in the juicy tissue, and it generally exhausts the plant to such a degree that it is no longer worth preserving. It is that succulent tissue which enables the cactus plants—one might compare them with the camels—to provide themselves beforehand with fluid, and thus to brave the rainless

season. Their anatomical structure also assists them in this respect in a peculiar manner. We know from the experiments of Hales that plants chiefly evaporate the water they contain through their leaves, and the cactus tribe have none. Their stem, too, unlike that of all other plants, is clothed with a peculiar leathery membrane, which wholly prevents evaporation. This membrane is composed of very strange, almost cartilaginous, cells, the walls of which are often traversed by elegant little canals. Its thickness varies in different species, and it is thickest, and therefore most impenetrable, in the Melocacti, which grow in the driest and hottest regions, while it is least remarkable in the species of *Rhipsalis*, which are parasites on the trees of the damp Brazilian forests.

Another striking point about this group is the formation of an extraordinary quantity of oxalic acid. If this acid were collected in large amount in the plant, it must necessarily be dead to it. The plant, therefore, takes up from the soil on which it grows a proportionate quantity of lime, which combines with the oxalic acid, forming insoluble crystals, which occur in abundance in all the Cactaceæ.

A third peculiarity is exhibited in the globular forms of *Melocactus* and *Mamillaria*, in the structure of the wood, which differs entirely from that of the common ligneous plants. Common wood, for example that of the poplar, is composed of long *wood-cells*, the walls of which are quite simple and uniform, and of cells containing air, the so-called *vessels*, the walls of which are very thickly beset

with little pores. Wholly unlike this, the wood of the cactus, above-mentioned, exhibits only short, spindle-shaped cells, inside which wind most elegant spiral bands, looking like little spiral staircases.

Lastly, the hair, spines, etc., situated in the places of leaves, deserve a special mention. Generally speaking, three forms may be distinguished, all three usually occurring together on the same spot. The first are very flexible, simple hairs, which form a little flat, soft cushion; among these is found a bunch of longish but thin spines. These it is chiefly which, on account of their peculiar structure, make the careless handling of the cactus plants so dangerous. These little spines are very thin and brittle, so that they readily break off, and are covered with barbed hooks directed backward from the point. When touched, a whole bunch penetrate the skin; if an attempt is made to draw them out, the separate spines break in the skin, and the fragments pierce in other places; when the hand is drawn over them, they catch in, and an insufferable itching, terminating in a slight inflammation, spreads over all the parts which have been touched. The *Opuntia ferox* is especially remarkable for these spines, whence its name, the *savage*. Among the hairs and smaller spines arise very long and thick spines, in different form and number, which give the best characters for the determination of the species. In some these are so hard and strong that they even lame the wild asses which incautiously wound themselves, when kicking off the spines to reach the means to still their thirst. In *Opuntia Tuna*, which is the kind most frequently used for hedges,

they are so large that even the buffaloes are killed by the inflammation following from these spines running into their breasts.

FUNGI.—HUGH MACMILLAN

FUNGI are intimately associated with autumn; unrobed prophets that see no sad visions themselves, but that bring to us thoughts of change and decay. Indeed, so close is this association that they may be called autumn's peculiar plants. The blue-bell still lingers on the wayside bank, and in the woods a few bright but evanescent and scentless flowers appear, but fungi and fruits form the wreath that encircles the sober and melancholy brow of autumn: fruits, the death of flower-life; fungi, the resurrection of plant-death. The seasonal conditions which arrest the further progress of all other vegetation, which cause the leaf to fall, and the flower to wither, and the robe of nature everywhere to change and fade, give birth to new forms of plant-life which flourish amid decay and death. From the relics of the former creations of spring and summer reduced to chaos, springs up a new creation of organic life; and thus nature is not a mere continuous cycle of birth, maturity, and decay, but rather a constant appearance of old elements in new forms.

In many respects they are the most mysterious and paradoxical of all plants. In their origin, their shapes, their composition, their rapidity of growth, the brevity of their existence, their modes of reproduction, their inconceivable number and apparent

ubiquity, they are widely different from every other kind of vegetation with which we are acquainted. In studying their history we walk amid surprises; and as we lift each corner of the veil, more and more marvelous are the vistas that reveal themselves.

The first thing that suggests remark in regard to these curious organisms is their origin. Incapable of deriving the elements of growth from the crude unorganized crust of the earth, they are parasitical upon organic bodies, and are sustained by animal and vegetable substances in a state of decomposition. That living and often nutritious objects should spring from festering masses of corruption and decay; that plants, endowed with all the organs and capacities of life, should start into existence from the dead tree that crumbles into dust at the slightest touch, or draw their nourishment from dried and exhausted animal excretions, which have lain for months under the influence of drenching rains and scorching sunbeams, is indeed a profound mystery of nature. No sooner does the majestic oak yield to the universal law of death, than several minute existences, which had been previously bound up and hid within its own, reveal themselves, seize upon the body with their tiny fangs, fatten and revel upon its decaying tissues, and in a short space of time reduce the patriarch and pride of the forest, which had braved the storms of a thousand years, into a hideous mass of touchwood, or into a heap of black dust. How strikingly do these plants illustrate the great fact, that in nature nothing perishes; that in the wonderful metamorphoses continually going on in the

universe there is change, but not loss; that there is no such thing as death, the extinction of one form of existence being only the birth of another, each grave being a cradle.

In many of their properties the fungi are closely allied to some members of the animal kingdom. They resemble the flesh of animals in containing a large proportion of albuminous proximate principles; and produce in larger quantity than all other plants azote or nitrogen, formerly regarded as one of the principal marks of distinction between plants and animals. This element reveals itself by the strong cadaverous smell, which most of them give out in decaying, and also by the savory meat-like taste which others of them afford. Of all known bodies, nitrogen is the most unstable. Its compounds are decomposed by slight causes; and, therefore, its presence in the animal frame is the cause of its activity and proneness to change. To this circumstance also is owing the fugacious character of fungi, their speedy growth and decay. Unlike other vegetables, fungi possess the remarkable property of exhaling hydrogen gas; and the great majority of species, like animals, absorb oxygen from the atmosphere, and disengage in return from their surface a large quantity of carbonic acid. By chemical analysis, they are found to contain, besides sugar, gum, and resin, a yellow spirit like hartshorn, a yellow empyreumatic oil, and a dry, volatile, crystalline salt, so that their nature is eminently alkaline, like animal substances extremely prone to corruption. The cream-like substance, of which the family of

Myxogastres is composed, resembles sarcode, and exhibits *Amœba*-like movements. Some of them contain such a quantity of carbonate of lime that a strong effervescence takes place on the application of sulphuric acid. Fungi feed like animals upon organic compounds elaborated by other plants. They contribute in no way as vegetables to the balance of organic nature.

Another property they possess, which connects them with animals, is their luminosity. This quality is very rare among plants, and is almost peculiar to the lowest order of animals, particularly those which inhabit the ocean. A species of mushroom (*Agaricus olearius*) grows on the olive-tree which is often luminous at night, and resembles the faint, lambent, flickering light emitted by the scales of fish and sea-animals kept in a dark place. Anomalous conditions of various species of *Polyporus*, *Hypoxylon*, etc., formerly referred to the genus *Rhizomorpha*, from their root-like appearance, cover the walls of dark mines with long, black, branchy, flat fibres, and give out a remarkably vivid phosphorescent light, almost dazzling the eye of the spectator. In the coal mines near Dresden, these fungoid bodies are said to cover the roof, walls, and pillars with an interlacing network of beautiful, flickering light like brilliant gems in moonlight, giving the coal mine the appearance of an enchanted palace on a festival night.

Fungi growing in mines exhibit the same characteristic colors which they display on the surface of the ground. Sometimes, however, species that

grow in caves, or in hollow trees, assume the most curious abnormal forms, their metamorphosis remaining incomplete, so that instead of producing fructification the whole fungus becomes a monstrous modification of the mycelium. Their love of seclusion and darkness gives an etiolated, sickly complexion to the whole tribe. In consequence of this habit, they are, as a rule, the most sombre of all plants, although instances occur in which the prevailing neutral tints are exchanged for the most brilliant scarlets and yellows. Green, which is the most frequent of all colors, the household dress of our mother earth, more characteristic of ferns, mosses, lichens, and algæ than of the higher plants, is almost unknown in the fungi; and even when it occurs, it is always more or less of a verdigris tint, and does not appear to be owing to the action of light and oxygen upon the contents of the cell.

Another of the remarkable peculiarities of the fungi is the extreme rapidity of their growth, a peculiarity more frequently to be seen among the lowest forms of animal life than among plants. They seem special miracles of nature, rising from the ground, or from the decaying trunk of the tree, full-formed and complete in all their parts in a single night, like Minerva from the head of Jupiter, or the armed soldiers from the dragon's teeth of Cadmus, sown in the furrows of Colchis. It has long been known that the growth of fungi takes place with great rapidity during thundery weather, owing, in all probability, to the nitrogenized products of the rain which then falls. One is surprised

after a thunderstorm in the beginning of August, or a day of warm, moist, misty weather, such as often occurs in September, to see in the woods thick clusters of these plants which had sprung into existence in the short space of twenty-four hours, covering almost every decayed stump and rotten tree. In tropical countries, stimulated by the intense heat and light, the rapidity of vegetable growth is truly astonishing; the stout, woody stem of the bamboo-cane, for instance, shooting up in the dense jungles of India at the rate of an inch per hour. In the Polynesian Islands, so favorable to vegetable life are the climate and soil that turnip, radish, and mustard seed when sown show their cotyledon leaves in twenty-four hours; melons, cucumbers, and pumpkins spring up in three days, and peas and beans in four. But swift as is this development of vegetation in highly favorable circumstances, the rapidity of fungoid growth, under ordinary conditions, is still more astonishing. These plants usually form at the rate of twenty thousand new cells every minute. The giant puff-ball (*Lycoperdon giganteum*), occasionally to be seen in fields and plantations, increases from the size of a pea to that of a melon in a single night; while the common stinkhorn (*Phallus impudicus*) has been observed to attain a height of four or five inches in as many hours.

Rapidity of growth in fungi is necessarily followed by rapidity of decay. Though some of the larger and more corky species last throughout the summer, autumn, and winter, and a few are perennial, growing on the same trunk for many years,

slowly and almost insensibly adding layer to layer, and attaining an enormous size, yet the vast generality of fungi are very fugacious. They are the ephemera of the vegetable kingdom. The entire life of most of the species ranges from four days to a fortnight or month; while there are numerous microscopic species of the mould family whose lives are so brief and evanescent as scarcely to allow sufficient time to make drawings of their forms.

Fungi are extremely simple in their organization. They bring us back to first principles, and reveal to us the secret manner in which Nature builds up her most complicated vegetable structures. They are composed entirely of cellular tissue, of a definite aggregation of loose, more or less oval, elliptical cells with cavities between them. These cells in many species may be seen by the naked eye, and consist of little closed sacs of transparent colorless membrane. Here is the starting-point of life. Such cells are the primary germ or element from which every living thing, whether plant or animal, is produced. The whole process of vegetable growth is but a continuous multiplication of these cells.

Although the structure of fungi is generally of a loosely cellular nature, yet they exhibit an astonishing variety of consistence. Each genus, and in many instances each species, displays a different texture. They range in substance from a watery pulp or a gelatinous scum to a fleshy, corky, leathery, or even ligneous mass. Some are mere thin fibres of airy cobweb spreading like a flocculent veil over decaying matter; while others resemble large, irregular

masses of hard, tough wood. Their qualities are also exceedingly various. Like the ferns, they all possess a peculiar odor by which they may be easily recognized, although it is somewhat different in different individuals, some smelling strongly of cinnamon and bitter almonds, others of onions and tallow, while others yield an insupportable stench. As regards their tastes, the fungi are equally diversified, being insipid, acrid, styptic, caustic, or rich and sweet. Some have no taste in the mouth while masticated, but shortly after swallowing there is a dry, choking, burning sensation experienced at the back of the throat, which lasts for a considerable time. Upward of 3,000 distinct species have been found and described in Britain alone; while more than 20,000 species altogether are known to the scientific world. In round numbers it may be said that fungi form about a third of the flowerless plants.

The following instances may be brought forward as illustrations of the remarkable shapes which many of the fungi exhibit. On the trunk of the oak, the ash, the beech, and the chestnut may occasionally be seen a fungus so remarkably like a piece of bullock's liver that it may be known from that circumstance alone. This is the *Fistulina hepatica*, or liver fungus. Its substance is thick, fleshy, and juicy, of a dark Modena red, tinged with vermilion. It is marbled like beet root and consists of fibres springing from the base, from which a red pellucid juice like blood slowly exudes. Of all vegetable substances this exhibits the closest resemblance to animal tissue. Even in the minutest particular it seems

to be a caricature of nature, a sportive imitation on an unfeeling oak tree of the largest gland of the animal body. Like the liver it is also nutritious, and forms a favorite article of food in Austria, though it is somewhat tough and acrid in taste. Another remarkable species of fungus, called Jew's Ears (*Hirneola Auricula-Judæ*), from its close resemblance to the human ear, clings to the trunks of living trees, particularly the elder, throughout the whole autumnal season. Another remarkable species, the *Tremella mesenterica*, common all the year round, on furze and sticks in woods, bears a strong resemblance to the human mesentery. It is of a rich orange color. This extraordinary resemblance which different fungi bear to the different parts of the animal body served to confirm the opinion of the ancient botanists and herbalists that they were animal structures, or at least intermediate links between the animal and vegetable kingdoms.

Although fungi in general are sober, nun-like plants, preferring quiet Quaker colors suitable to the dim, secluded places which they usually affect, yet some of them depart widely from this soberness and exhibit themselves in the most gaudy hues. Some species are of a brilliant scarlet color; others of a bright orange. Many are yellow, while a few don the imperial purple. In short, they are to be found of every color, from the purest white to the dingiest black, dark emerald or leaf-green alone excepted. Some are beautifully zoned with iridescent convoluted circles, or broad stripes of different hues.

Some shine as if sprinkled with mica; others are smooth as velvet, and soft as kid-leather.

Let us take a specimen of one of the most perfectly formed and highly developed fungi, the common, shaggy mushroom, for instance (*Agaricus procerus*), which is also the most familiar example, and endeavor to point out the peculiarities of its structure. Like all plants, it consists of two distinct parts, the organs of nutrition or vegetation and the organs of reproduction; the former bearing but a very small proportion in size to the latter. The organs of nutrition or vegetation consist of grayish-white interlacing filaments, forming a flocculent net-like tissue, and penetrating and ramifying through the decaying substances on which the mushroom grows. These filaments are formed of elongated colorless cells. They are developed under ground, and in other plants would be called roots. This part of the fungus is called by botanists mycelium, and is popularly known as the spawn by which the mushroom is frequently propagated. In favorable circumstances this mycelium spreads with great rapidity, sometimes, especially when prevented from developing organs of reproduction, attaining enormous dimensions. It may be kept dormant in a dry state for a long time, ready to grow up into perfect plants when the necessary heat and moisture are applied. When the requisite conditions are present and the mycelium begins to develop the reproductive tissue, there is formed at first a small, round tubercle, in which the rudiments or miniature organs of the future plant may, after a while, be distinctly traced.

In this infantile condition, the mushroom is covered completely with a fine, silky veil or volva, which afterward disappears. The tubercle rapidly increases, until at last it produces from its interior a long, thick, fleshy stem, or stipe, surmounted by a pileus, or round convex, concave, or flat cap, similar to that anciently worn by the Scottish peasantry. This is the organ of reproduction, equivalent to the thecæ of mosses and the flowers of phanerogamous plants. This cap is covered with a veil or wrapper, which is ruptured at a certain stage, and retires to form an annulus or ring round the stem. When it is removed from the under side of the pileus, a number of vertical plates or gills is revealed of a pale pinkish-yellow or white color, different from the rest of the plant, and radiating round the cap from a common centre.

The whole of this apparatus is called the hymenium. Each of the gills when examined under the microscope is found to consist of a number of elongated cells called basidia, united together on both sides of a cellular stratum, and bearing at their summits four minute spores supported on tiny stalks. It is by these spores, which become detached when ripe, that the plant is propagated. These spores are so very minute that many thousands of them are required to make a body the size of a pin-head; and they are capable of enduring a temperature at least equal to that of boiling water. While upon the subject of spores I may mention here that the remarkable elastic force with which many of the fungi eject their seed has often excited attention, and is fully

equal to anything of the same kind observed among flowering plants.

The mushroom may be regarded as an ideal fungus of the highest type. There are six large orders of fungi in which the organs of fructification are widely different. The first order is called Hymenomycetes, or naked fungi, because the seed-bearing organs are naked or placed externally. This is the largest, most important, and most highly developed order. The mushroom, toadstool, chantarelle, amadou, are familiar examples of it. The hymenium assumes various shapes in the different genera. In the mushroom it forms gills, in the toadstool tubes, in the chantarelle veins, in the amadou pores, and in the hydnum spines. The second order, called Gasteromycetes, has the seed-bearing organs inclosed in a membraneous covering, like the stomach of an animal, whence the name. The stinkhorn, the Melanogaster, or red truffle of Bath, the bird's-nest fungus, and the puff-ball are familiar examples of this order. Some of the forms, such as *Stemonitis fusca*, common on rotten wood, are exceedingly elegant. The third order is called Concomycetes, or dust-fungi, because the spore-cases are produced beneath the epidermis of plants, or the matrix in which they are developed, in the form of a minute collection of dust, entirely destitute of any covering or receptacle, except that which is furnished by the skin of the plant raised around them. This class is the most destructive of the whole tribe. Smut, bunt, and rust are too familiar examples of this most notorious class. The fourth order is called Hy-

phomycetes, or web-like fungi, because the spores are free, developed or naked filament whose terminal cells are often transformed into a series of spores like a row of beads. The general appearance of the plants belonging to this order is that of a quantity of dust-like seeds, imbedded in a flaky, cottony substance, like a spider's web. The different kinds of common mould, blue, yellow, and green, the potato disease, caterpillar and silkworm blights, and various kinds of mildew are common examples of this order. The fifth order, called Physomycetes, is distinguished by its stalked sacs containing numerous spores, or sporidea. It is the smallest of all the orders. The black, felty cellar-fungus and the gray mucor or mould on preserves are familiar illustrations of this order. The sixth and last order is that of the Ascomycetes, or asci-bearing fungi, whose spores, generally eight in number, are produced in the interior of groups of elongated sacs or thecæ contained in fleshy, leathery, or wart-like fructification. These fungi, of which the morel, truffle, and vine disease are well-known examples, resemble lichens in every respect except that they are produced on decaying substances, and are possessed of a mycelium or spawn destitute of the green cellular matter of lichens.

Although fungi are in an especial manner capable of universal dissemination, yet we find that in their geographical distribution they are as much restricted as other plants. Some representatives of the class are found in every part of the world, and some particular species have the power of indefinite extension

and localization, but, as a whole, like the higher cryptogams, they can only spread within certain limited areas. In tropical forests, where the exuberance of the vegetation excludes the rays of the sun, and creates the dim light and the still, moist air which they love, and where there is always an immense quantity of decaying organic matter, we might expect to find them in the greatest quantity and luxuriance. But, strange to say, fungi, as a class, are comparatively rare in tropical woods. Their headquarters seem to be in northern latitudes, where the temperature is mild and genial, and where there is a constant supply of moisture. Professor Fries of Upsal, the presiding genius of these plants, gathered in Sweden, within a space of ground not exceeding a square furlong, more than two thousand distinct species. "This country," says Mr. Berkeley, "with its various soils, large mixed forests, and warm summer temperature, seems to produce more species than any part of the known world; and next in order, perhaps, are the United States as far south as South Carolina, where they absolutely swarm. A moist autumn after a genial summer is most conducive to their growth, but cold, wet summers are seldom productive. The portion of the Himalayas which lies immediately north of Calcutta is, perhaps, almost as prolific in point of individuals as the countries named above, but the number of species on examination proves far less than might at first have been suspected. It is probably not a fifth of what occurs in Sweden. Great Britain, though possessing a considerable list of species, is not abundant in indi-

viduals, except as regards a limited number of species. The exuberance, even in the most favorable autumn, is not to be compared with that of Sweden or many parts of Germany." They are found in Arctic and Antarctic regions, almost as far as the limits of vegetation. They penetrate to the dreary regions of Greenland and Lapland, supplying the natives with their tinder, and with an excellent styptic for stopping blood and allaying pain; and they announce to the hapless exiles of Siberia, when their gayly colored forms spring forth from the crevices of the rocks, and in the dark haunts of the gloomy fir-woods, that the stormy blasts of winter and spring are past, and that the summer and autumn, those short, sweet seasons of indescribable beauty and pleasure, have come.

Certain genera and species occur only in tropical and sub-tropical regions, having their northern limit in the north of Africa or the coast of the Mediterranean. Several genera and species are confined to New Zealand, others to Ceylon and Java, others to the Cape de Verde Islands and the United States. Like flowering plants, the fungi of different climates and zones are found at different heights along the sides of tropical mountains that rise above the snow-line. In the Sikkim Himalayas, *Polyporus Sanguineus*, and *Xanthopus* luxuriate in the stifling tropical woods at the base of the hills; higher up the fungi peculiar to Ceylon and Java grow among the palms and tree-ferns of the mid regions; higher still, the species of Southern Europe abound in the deodar forests and among the rhododendron thickets of the

upper heights; while below the line of perpetual snow, on grassy slopes and amid scrubby vegetation, may be seen species, if not identical with, at least very closely allied to, those of Britain and Sweden. One species has been found at a height of 18,000 feet, which is probably the highest range of fungoid growth.

FAIRY RINGS

—A. B. STEELE

THE green circles, or parts of circles in pastures, popularly known as fairy rings, have given rise to many curious beliefs and sayings, and their marvelously rapid growth has struck the uncultivated as a supernatural phenomenon. The prevalent belief was that they were caused by the midnight dancing and revelry of the fairies; and Shakespeare speaks of the elves—

“Whose pastime
Is to make midnight mushrooms.”

In the west of England these rings are called “hogs’ tracks.” In the myths and folklore of Sweden they are said to be enchanted circles made by fairies. The elves perform their midnight *stimm*, or dance, and the grass produced after the dancing is called *ail-fexing*. A belief prevails in some parts of this country that any one treading within the magic circles either loses consciousness, or can not retrace his steps. Many absurd theories have been propounded as to the cause of these rings. Aubrey, who wrote the

Natural History of Wiltshire, in the Seventeenth Century, says that they are generated from the breaking out of a fertile subterraneous vapor, which comes from a kind of conical concave, and endeavors to get out at a narrow passage at the top, which forces it to make another cone, inversely situated to the other, the top of which is the green circle. Another remarkable theory by a writer, quoted in Captain Brown's notes to White's *Selborne*, attributes these rings to the droppings of starlings, which when in large flights frequently alight on the ground in circles, and are sometimes known to sit a considerable time in these annular congregations. It was also thought that such circles were caused by the effects of electricity, and for this belief the withered part of the grass within the circles may have given foundation. Priestley was a strong advocate of the electric theory, and was supported by many eminent men of his time.

"So from the clouds the playful lightning wings,
Rives the firm oak, and prints the fairy rings,"

says Dr. Darwin, and appends a note that flashes of lightning, attracted by the moister part of grassy plains, are the actual cause of fairy rings. Archæologists suggested that they might be the remains of circles formed by the ancient inhabitants of Britain, in the celebration of their sports, or the worship of their deities. Naturalists formerly came to the conclusion that the rings were caused by the underground workings of insects, and a few years ago a writer in the *Transactions of the Woolhope Club* at-

tempted to prove that they were the work of moles. These so-called fairy rings, which have long puzzled philosophers, are caused by a peculiar mode of the growth of certain species of fungi, the peculiarity being their tendency to assume a circular form. A patch of spawn arising from a single seed, or a collection of seeds, spreads centrifugally in every direction and forms a common felt from which the fruit rises at its extreme edge; the soil in the inner part of the disk is exhausted, and the spawn dies or becomes effete there while it spreads all round in an outward direction and produces another crop, whose spawn spreads again. The circle is thus continually enlarged and extends indefinitely until some cause intervenes to destroy it. This mode of growth is far more common than is supposed, and may be constantly seen in our woods, when the spawn can be spread only in the soil or among the leaves and decaying fragments which cover it. In the fields this tendency is illustrated by the formation of circles or parts of circles of vigorous dark green grass. To get at the cause, however, of the rank growth of the grass composing these rings is not without its difficulties still. It is known that fungi exhaust the soil of plant-food and store it up in their own substance. In the case of these fairy rings they take up from the soil the organic nitrogen which is not available to the grasses, and in some way become the medium of the supply of the soil-nitrogen to the grasses forming the circle. How exactly the nitrogen, one of the most important plant-foods, is fixed by these fungi has not yet been discovered, but the grasses imme-

diately following the fungi have been analyzed and found to contain a larger proportion of nitrogen than the herbage in the neighborhood.

Fairy rings are sometimes distinctly seen visible on a hillside from a considerable distance, many of them being years old and of enormous dimensions. One recorded from Stebbing, in Essex, measured 120 feet across, the grass all over it being very coarse and dark green in color, chiefly of the cock's-foot species. Rings found in pasture lands are composed of several species of fungi, all of which are edible. They are most frequently observed to be formed by *marasmius oreades*, a little buff mushroom which most people know under the name of champignons, or Scotch bonnets. It is abundant everywhere. For several months in the year it comes up in successive crops in great profusion after rain, and continually traces fairy rings among the grass.

Another and very delicious mushroom, *agaricus prunulus*, sometimes called the plum agaric, and known in America as the French mushroom, occasionally succeeds a crop of the champignons which had recently occupied the same site. It is sometimes found throughout the summer, but autumn is the time to look for it. The only other good edible fungi to be found in any quantity forming rings are the horse-mushroom, the giant-mushroom, and St. George's mushroom. The first two are excellent eating, and to be had in the late summer and autumn; but the last are reproduced in rings in spring every year—the circle continuing to increase till it breaks up into irregular lines. The continuity of the circle is a sign

to the collector that there will be a plentiful harvest next spring, while the breaking up is conclusive proof that it is going to disappear from that place. Spring is the only time it makes its appearance, and the proper place to look for it is the borders of woodlands. It is one of the most savory of mushrooms, and difficult to be confounded with any other, as it appears at a time when scarcely any other kinds occur. Like the champignon, it has an advantage over the common mushroom in the readiness with which it dries, and is largely employed in the preparation of ketchup. It is called St. George's mushroom on account of its appearing about St. George's Day, the 23d of April, and among the peasants of Austria is looked on as a special gift from that saint. In Italy a basket of early specimens is a favorite present among all classes.

LICHENS.—HUGH MACMILLAN

LICHENS are exceedingly diversified in their form, appearance, and texture. About five hundred different kinds have been found in Great Britain alone, while upward of three thousand species have been discovered in different parts of the world by the zealous researches of naturalists. In their very simplest rudimentary forms, they consist apparently of nothing more than a collection of powdery granules, so minute that the figure of each is scarcely distinguishable, and so dry and utterly destitute of organization that it is difficult to believe that any vitality exists in them. Some of these form

ink-like stains on the smooth tops of posts and felled trees; others are sprinkled like flower of brimstone or whiting over shady rocks and withered tufts of moss; while a third species is familiar to every one, as covering with a bright green incrustation the trunks and boughs of trees in the squares and suburbs of smoky towns, where the air is so impure as to forbid the growth of all other vegetation. It also creeps over the grotesque figures and elaborate carving on the roofs and pillars of Roslin Chapel, near Edinburgh, and gives to the whole an exquisitely beautiful and romantic appearance. One species, the *Lepraria Jolithus*, is associated with many a superstitious legend. Linnæus, in his journal of a tour through Æland and East Gothland, thus alludes to it: "Everywhere near the road I saw stones covered with a blood-red pigment, which on being rubbed turned into a light yellow, and diffused a smell of violets, whence they have obtained the name of violet stones; though, indeed, the stone itself has no smell at all, but only the moss with which it is dyed." At Holywell, in North Wales, the stones are covered with this curious lichen, which gives them the appearance of being stained with blood; and, of course, the peasantry allege that it is the ineffaceable blood which dropped from Ste. Winifred's head, when she suffered martyrdom on that sacred spot. A higher order of lichens (*Bæomyces*) is furnished besides this powdery crust, with solid, fleshy, club-shaped fructification like a minute pink fungus; while a singularly beautiful genus (*Calicium*), usually of a very vivid yellow color, spreading in indefinite

patches over oaks and firs, is provided with capsules somewhat like those of the mosses.

Most of the crustaceous lichens are merely gray filmy patches inseparable from their growing places, indefinitely spreading, or bounded by a narrow dark border, which always intervenes to separate them when two species closely approximate, and studded all over with black, brown, or red tubercles. The foliaceous species are usually round rosettes of various colors, attached by dense black fibres all over their under-surface, or by a single knot-like root in the centre. Some are dry and membranaceous; while others are gelatinous and pulpy, like aerial seaweeds left exposed on island rocks by the retiring waves of an extinct ocean. Some are lobed with woolly veins underneath; and others reticulated above, and furnished with little cavities or holes on the under-surface. The higher orders of lichens, though destitute of anything resembling vascular tissue, exhibit considerable complexity of structure. Some are scrubby and tufted, with stem and branches like miniature trees; others bear a strong resemblance to the corallines of our seashores; while a third class, "the green-fringed cup-moss with the scarlet tip," as Crabble calls it, is exceedingly graceful, growing in clusters beside the black peat moss or underneath the heather tuft,

"And, Hebe-like, upholding
Its cups with dewy offering to the sun."

As an illustration of the extraordinary appearance which lichens occasionally present, I may describe

the *Opegrapha*, or written lichen, perhaps the most curious and remarkable member of this strange tribe. In her cacti and orchids sportive Nature often displays a ludicrous resemblance to insects, birds, animals, and even the "human face and form divine"; but this is one of the few instances in which she has condescended to imitate in her vegetable productions the written language of man. A cryptogam is in this case a cryptogram! The crust of the curious autograph of nature is a mere white tartareous film of indefinite extent, sometimes bounded by a faint line of black, like a mourning letter. It spreads over the bark of trees, particularly the beech, the hazel, and the ash. On the birch-tree—whose smooth, snow-white vellum-like bark seems designed by nature for the inscription of lovers' names and magic incantations—it may often be seen covering the whole trunk. The fructification consists of long wavy black lines, sometimes parallel like Runic inscriptions; sometimes arrow-headed, like the cuneiform characters engraved upon the monumental stones of Persepolis and Assyria; and sometimes gathered together in groups and clusters, bearing a strong resemblance to Hebrew, Arabic, or Chinese letters.

Lichens are extremely simple in their construction. They are composed of two parts, the nutritive and the reproductive system. The nutritive portion is called the thallus, which, in the typical plant, spreads equally on all sides from the original point of development, in the form of an increasing circle; the circumference of which is often healthy, while the central parts are decayed or completely wanting.

Nature has bestowed upon the lichens a peculiar mode of reproduction which appears quite different from that of the higher orders of the vegetable kingdom; and yet they are propagated with as unerring certainty and as great rapidity as the most prolific family of flowers. Every one who has an attentive eye must have often noticed the curious round disks or shields, usually of a different color from the rest of the plant, with which their surface is often studded. These are called apothecia, and correspond with the flowers of the higher plants; for in them are lodged the seeds or germs by which the lichens are perpetuated. When examined under the microscope they are found to consist of a number of delicate flask-shaped cells, called thecæ, containing 4, 8, 12, or 16 sporidia, that is, cells of an oval form, with spores or seeds in their interior. The mode in which these spores are ejected affords as wonderful a proof of design as in the case of ferns and mosses.

Lichens are very slow-growing plants. They spring up somewhat rapidly during the first year or two, as is evinced by the luxurious growth which they form over young fruit-trees and espaliers in gardens; but after a circular frond is formed, they subside into a dormant state, in which they remain unaltered for many years. The foliaceous and scrubby species are the most fugacious, though even these have great powers of longevity. We have no data from which to ascertain the age of tartareous species, which adhere almost inseparably to stones. Some of them are probably as old as any living organisms that exist on the earth.



Typical Nuts and Tree-Products

1, Cinnamon; 2, Camphire (Camphor); 3, Pomegranate; 4, Sycamore Figs;
5, Olive Twig and Fruit; 6, Theobroma Cacao (Chocolate)

In the Arctic regions—those outer boundaries of the earth where eternal winter presides—these humble plants constitute by far the largest proportion of the flora, and by their prodigious development, and their wide social distribution, give as marked and peculiar a character to the scenery as the palms and tree-ferns impart to the landscapes of the tropics. In the Southern Hemisphere also lichens extend almost to the pole. They mark the extreme limit at which land vegetation has been found; one scrubby species, with large, deep, chestnut-colored fructification, called *Usnea fasciata*, having been observed by Lieutenant Kendal on Deception Island, the Ultima Thule of the Antarctic regions.

In tropical countries, where there is not too much moisture and shade, the trees are shaggy with lichens; and some of the most magnificent species, both as regards size and color, have been gathered in the Cinchona forests which clothe the lower slopes of the Andes, and in the warmer and more densely wooded parts of Australia and New Zealand. The thick impervious forests of Brazil, however, are said to be almost destitute of them. On the Alps of Switzerland the last lichens are to be found on the highest summits, attached to projecting rocks, exposed to the scorching heats of summer and the fierce blasts of winter; and from forty to forty-five kinds have been found in spots, surrounded by extensive masses of snow, between 10,000 and 14,780 feet above the level of the sea. It is interesting to know that the only plant found by Agassiz near the top of Mont Blanc was the *Lecidea geographica*, a very beautiful

lichen, which covers the exposed rocks on the sides and summits of all the British hills, with its bright-green, map-like patches. This species was also gathered by Dr. Hooker at an elevation of 19,000 feet on the Himalayas, and occupied the last outpost of vegetation which gladdened the eyes of the illustrious Humboldt, when standing within a few hundred feet of the summit of Chimborazo, the highest peak of the Andes.

The *Lecidea geographica* affords, I may mention, the most remarkable example of the almost universal diffusion of lichens, being the most Arctic, Antarctic, and Alpine lichen in the world—facing the savage cliffs of Melville Island in the extreme north, clinging to the volcanic rocks of Deception Island in the extreme south, and scaling the towering peak of Kinchin-junga, the most elevated spot on the surface of the earth.

It is somewhat remarkable that Alpine lichens generally are more or less of a brown or black color. This peculiarity seems to be owing to the presence of usnine or usnic acid, which in a pure state is of a green color, as in the lichens which grow in shady forests, but which becomes oxidized, and changes to every shade of brown and black, when exposed to the powerful agencies of light and heat on the bleak barren rocks on the mountain side and summit. These gloomy lichens, associated as they always are with the dusky tufts of that singular genus of mosses, the *Andræas*, give a very marked and peculiar character to many of the Highland mountains, especially to the summit of Ben Nevis, where they creep, in the

utmost profusion, over the fragments of abraded rocks which strew the ground on every side, otherwise bare and leafless, as was the world on the first morning of creation, and reminding one of the ruin of some stupendous castle, or the battlefield of the Titans. Some of the Alpine lichens, however, are remarkable for the vividness and brilliancy of their colors. The mountain cup-moss, with its light green stalk clothed and filigreed with scales and emerald cup studded round with rich scarlet knobs, presents no unapt resemblance to a double red daisy. It grows in large clusters on the bare storm-scalped ridges, and forms a kind of miniature flower-garden in the Alpine wilderness. The loveliest, however, of all the mountain lichens is the *Solorina crocea*, which spreads over the loose mould in the clefts of rocks, and on the fragments of comminuted schist on the summits of the highest Highland mountains, forming patches of the most beautiful and vivid green, varied, when the under side of the lobes is curled up, by reticulations of a very rich orange-saffron color. This species is not found at a lower elevation than 4,000 feet; hence it is unknown in England, Ireland, and Wales, whose highest mountains fall considerably short of this altitude. I have gathered it on Cairngorm, Ben Macdhui, and Ben Lawers. In this last locality, which is well known to botanists as exhibiting a perfect garden of rare and beautiful Alpine plants, it grows in greater abundance, I believe, than in any other spot in the Highlands.

On account of the large quantity of starchy matter

which they contain, they often considerably, and sometimes even entirely, form the diet of man and animals in those dreary inhospitable regions where the wintry rigor, or the scorching heat of the climate, forbids all other kinds of vegetation to grow. Every one is familiar with the fact that the reindeer-moss (*Cladonia rangiferina*) forms altogether the food of that animal during the prolonged northern winters. This lichen grows sparingly in little tufts among the heather in Scotland, and sometimes whitens the sides and plateaus of the Highland hills, covering bare and verdureless places where the snow first falls in winter and lingers longest in summer; but it is in the vast sandy plains, called by the Laplanders *Flechten-tundra* and *Moos-tundra*, as lichens or mosses predominate, which border the Arctic Ocean, that it flourishes in the greatest profusion and luxuriance. There it completely covers the ground with its snowy tufts, and occupies as conspicuous a place in the economy of nature as the grass in warmer regions. Linnæus says that no plant flourishes so luxuriantly as this in the pine-forests of Lapland, the surface of the soil being completely carpeted with it for many miles in extent; and that if by an accident the forests are burned to the ground, in a very short time the lichens reappear, and resume all their original vigor.

When the ground is covered with hard and frozen snow, so that the reindeer can not obtain its usual food, it finds a substitute in a very curious lichen called *rock-hair* (*Alectoria jubata*), which covers with its beard-like tufts the trunk of almost every

tree. In most severe weather the Laplanders cut down whole forests of the largest trees, that their herds may be enabled to browse at liberty upon the tufts which cover the higher branches. The vast, dreary pine-forests of Lapland possess a character which is peculiarly their own, and are perhaps more singular in the eyes of the traveler than any other feature in the landscapes of that remote and desolate region. This character they owe to the immense number of lichens with which they abound. The ground instead of grass is carpeted with dense tufts of the reindeer moss, white as a shower of new-fallen snow; while the trunks and branches of the trees are swollen far beyond their natural dimensions with huge, dusky, funereal bunches of the rock-hair hanging down in masses, exhaling a damp earthy smell, like an old cellar, or stretching from tree to tree in long festoons, waving with every breath of wind, and creating a perpetual melancholy twilight.

Another beard-like lichen (*Usnea florida*), often growing along with the rock-hair, is gathered in great quantities in North America, from the pine-forests, and stored up as winter fodder for cattle in inclement seasons. Goats, and especially deer, are fond of it; and in winter when other food is scarce, they hardly leave a vestige of it on the trees within their reach. The tortoises of the small rocky islands of the Galapagos Archipelago subsist almost entirely upon it. In Scotland it is one of the most picturesque ornaments of the pine-forests. When fully developed it forms tufts nearly a foot in length. It is quite a miniature larch-tree, with root, stem, and

most intricate branches and twigs. Its color is pale sea-green; and a central white thread or pith runs through the main stem, and lateral branches, on which, when cracked with age, the segments of cellular tissue are strung like beads on a necklace. A kind of farinaceous meal is plentifully sprinkled on the ultimate branches. Altogether it is one of the most beautiful and interesting lichens. A reddish variety grows in such quantities on trees of *Conyza arborea*, forming the alley near Napoleon Bonaparte's residence in St. Helena, that this hanging vegetation is the first thing that attracts the eye of the visitor.

But it is not to animals alone that lichens furnish a supply of food. There are few, I presume, who are not acquainted with some particulars regarding the history and uses of that remarkable lichen sold in chemists' shops under the name of *Cetraria islandica*, or Iceland moss. What barley, rye, and oats are to the Indo-Caucasian races of Asia and western Europe; the olive, the grape, and the fig to the inhabitants of the Mediterranean districts; the date-palm to the Egyptian and Arabian; rice to the Hindu; and the tea-plant to the Chinese—the Iceland moss is to the Laplanders, Icelanders, and Esquimaux.

It may be mentioned that, notwithstanding its name, the Iceland moss is not only more plentiful, but more largely developed in all its varied forms in Norway than in Iceland, and it is in Norway that it is now almost exclusively collected for the European market.

Those who have read the affecting account which

Franklin and Richardson give of their expedition to Arctic America must be familiar with the name of the Tripe de Roche, which occurs on almost every page, and is intimately associated with the fearful sufferings which these brave men endured, a part of which only would have sufficed to unseat the reason of most individuals. During their long and terrible journey from the Coppermine River to Fort Enterprise, one of the stations of the Hudson's Bay Company, in the almost total absence of every other kind of salutary food, their lives were supported by a bitter and nauseous lichen, to which the name of Tripe de Roche (*Gyrophora*) has been given as if in mockery.

The Tripe de Roche consists of various species of *Gyrophora*—black, leather-like lichens, studded with small black points like coiled wire buttons, and attached by an umbilical root, or by short strong fibres to rocks on the mountains. Some of them bear no unapt resemblance to a piece of shagreen; while others appear corroded, like a fragment of burned skin, as if the rock on which they grew had been subjected to the action of fire. They are found in cold exposed situations on Alpine rocks of granite or micaceous schist, in almost all parts of the world—on the Himalayas and Andes as well as the British mountains. But it is in the Arctic regions alone that they luxuriate, covering the surface of every rock, to the level of the seashore, with a gloomy Plutonian vegetation that seems like the charred cinders and shriveled remains of former verdure and beauty.

MOSESSES.—HUGH MACMILLAN

MOSSES belong to the foliaceous or highest division of flowerless plants. Although consisting entirely of cellular tissue and increasing by simple additions of matter to the growing point or apex of parts already formed, they point to far higher orders of vegetation; they are prefigurations of the flowering plants, epitomes of archetypes in trees and flowers. There is nothing in the appearance or structure of the lichens, fungi, or algæ to remind the popular mind of higher plants; they form, as it were, a strange microcosm of their own—a perfectly distinct and peculiar order of vegetable existence. But when we ascend a step higher and come to the mosses, we find for the first time the rudimental characters and distinctions of root, stem, branches, and leaves—we recognize an ideal exemplar of the flowering plants, all whose parts and organs are, as it were, sketched out, in anticipation, in these simple and tiny organisms. Through the small, densely cushioned, moss-like Alpine flowers, they approximate analogically to the phanerogamous plants in their leaves and habits of growth; and through the cone-like spikes of the club-mosses they approximate to the pine tribe in their fructification. From both these classes of highly organized plants, however, they are separated by wide and numerous intervening links. But still it is curious and interesting to find in them an exemplification of the universal teleology of nature—the humblest typical forms pointing to

the grand archetypes, the simplest structures anticipating and prefiguring the most highly organized and complicated.

In no tribe of plants is there so great a similarity between the different species as in the mosses. This remarkable similarity, concealing a no less remarkable diversity, has led to the popular belief that there is only one kind of moss. Closely examined, however, by an educated eye, their exceeding variability of form will at once become evident, some being slender, hair-like plants; some resembling miniature fir-trees, others cedars, and others crested feathers and ostrich-plumes. In size they vary from a minute film of green scarcely visible to the naked eye to wreaths and clusters several feet in length. Nor are their colors less variable, ranging from white through every shade of yellow, red, green, and brown, to the deepest and most sombre black.

The leaves of mosses are their most prominent parts. To the careless and superficial eye, accustomed to look at a tuft of moss as merely a patch of velvety greenness, creeping over an old tree or dike, the leaves of all mosses may appear precisely similar; but the attentive observer who examines them under a microscope will find that the leaves of different kinds of trees are not more distinct from each other than are those of the mosses.

The organs of fructification, however, with which mosses are furnished, are, perhaps, the most wonderful parts of their economy. When the requisite conditions are present, these are generally developed during the winter and spring months, and may be

easily recognized by their peculiar appearance. At first a forest of hair-like stalks, of a pale pink color, rises above the general level of the tuft of moss to the height of between one and three inches, giving to the moss the appearance of a pincushion well provided with pins. These stalks, through course of time, are crowned with little wen-like vessels called capsules, which are covered at an early stage with little caps, like those of the Normandy peasants, with high peaks and long lappets—in one species bearing a remarkable resemblance to the extinguisher of a candle—a curious provision for protecting them alike from the sunshine and the rain, until the delicate structures underneath are matured. When the fruit-stalk lengthens and the capsules swell, this hood or cap is torn from its support and carried up on the top of the seed-vessel, much in the same way as the common garden annual, the *Eschscholtzia* or Californian poppy is borne up on the summit of the cone-like petals before they expand. When the seed-vessel is riper it falls off altogether, and discloses a little lid covering the mouth of the capsule, which is also removed at a more advanced stage of growth. The mouth of the seed-vessel is then seen to be fringed all round with a single or double row of teeth, which closely fit into each other, and completely close up the aperture.

It is extremely interesting to note that the leaf is the type of the plant in the moss as in the flowering plant; the veil being merely a convolute leaf, the lid a metamorphosed leaf, the teeth one or more whorls of minute, flat leaves. It is by no means rare

to find individual mosses in which leaves appear at the top of the fruit-stalk in place of the spore-case, just as happens in the phyllode of flowering-plants, when the colored parts of the flower are converted into green foliage.

Mosses possess in a high degree the power of reproducing such parts of their tissue as have been injured or removed. They may be trodden under foot; they may be torn up by the plow or the harrow; they may be cropped down to the earth, when mixed with grass by graminivorous animals; they may be injured in a hundred other ways; but, in a marvelously short space of time they spring up as verdant in their appearance and as perfect in their form as though they had never been disturbed.

Mosses also possess the power of resisting, perhaps to a greater extent than most plants, the injurious operation of physical agents; and this likewise is a wise provision to qualify them for the uses which they serve in the economy of nature. The influence of heat and cold upon many of them is extremely limited; some species flourishing indiscriminately on the mountains of Greenland and the plains of Africa. They have been found growing near hot springs in Cochin-China, and fringing the sides of the geysers of Iceland, where they must have vegetated in a heat equal to 186 degrees; while, on the other hand, they have been gathered in Melville Island at 35 degrees, or only just above the freezing-point. Though frozen hard under the snow-wreaths of winter for several months, their vitality is unimpaired; and though subjected to the scorching rays of the summer's sun

they continue green and unblighted. Even when thoroughly desiccated into a brown, unshapen mass that almost crumbles into dust when touched by the hand, they revive under the influence of the genial shower, become green as an emerald; every pellucid leaf serving as a tiny mirror on which to catch the stray sunbeams. Specimens dried and pressed in the herbarium for half a century, have been resuscitated on the application of moisture, and the seed procured from their capsules has readily germinated. They grow freely in the Arctic regions, where there is a long twilight of six months' duration; and they luxuriate in the dazzling, uninterrupted light of the tropics. They are found thriving amid moist, steam-like vapors, with orchids and tillandsias, in the deep American forests; and they may be seen in tufts here and there on the dry and arid sands of the Arabian deserts. It matters not to the healthy exercise of their functions whether the surrounding air be stagnant or in motion, for we find them on the mountain top amid howling winds and driving storms, and in the calm, silent, secluded wood, where hardly a breeze penetrates to ruffle their leaves.

Unlike the ferns, the size and number of which gradually diminish in passing from tropical to temperate countries, the maximum of mosses is found in cold climates, increasing in luxuriance, beauty, and abundance as we approach the North Pole. Like the ferns, moisture and shade are highly favorable to their growth and well-being; hence, as a rule, they produce a larger number of species and individuals, and spread over wider areas in islands and

the vicinity of rivers and lakes than in the interior of continents, unless when well wooded and watered. Their favorite habitats appear to be rocky dells or ravines at the foot of mountains, with streamlets murmuring through them and dense trees interweaving their foliage over their sides and creating a dim twilight in the recesses beneath. In such hermit seclusions the botanist may expect to reap the richest harvest of species.

Mosses, in many instances, are limited to rocks and soils of the same mineral character; their limits of distribution, and of the rocks and soils possessing such character being identical. For instance, some are confined to limestone districts and chalk cliffs; a calcareous soil being indispensable to their existence. Others affect granite; numerous species luxuriate in soil formed by the disintegration of micaceous schist; while not a few are found growing chiefly on sandstone and clay. Some are found only on and near the seashore; others are confined to the beds of streams and cliffs moistened by the spray of cascades, where, however impetuous the torrent may be, they cling tenaciously to the rocks and form carpets of greenest verdure for the white, glistening feet of the descending waters. Some are restricted exclusively to trees whose trunks and boughs they clasp like emerald bracelets; others lead a lonely, hermit-like existence in the dim moist caves and crevices of rocks, where they are discovered only by the glistening of a stray adventurous sunbeam on the drops of dew trembling upon their shining golden leaves.

Mosses are sometimes found in an isolated state as single individuals, but they are far oftener found in a social condition. It is a peculiarity of the family to grow in tufts or clusters, the appearance of which is always distinct and well-marked in different species, and often affords a specific character. This disposition to grow together, which is exhibited in no other plants so strongly, redeems them from the insignificance of their individual state, and enables them to modify in many places the appearance of the general landscape. As social plants they often cover vast districts of land. Along with the lichens they give a verdant appearance to the desert steppes of Northern Europe, Asia, and America. Mixed with grass they luxuriate in parks, lawns, and meadows, particularly in moist, low-lying situations. They spread in large patches over the ground in woods and forests; and at a certain elevation on mountain ranges they take exclusive possession of the soil, forming immense beds into which the foot sinks up to the ankles at every step, bleached on the surface by the sunshine and rain, blackened here and there by dissolving wreaths of snow which lie upon them through all the summer months, and gradually decomposing underneath into black vegetable mould.

The plants whose peculiarities have been described in the preceding pages are called Urn Mosses, their fructification being urn-shaped, furnished with teeth and closed with a lid. There is another large class called Scale-Mosses, so closely allied to the true mosses that they are frequently confounded even by an educated eye. There are upward of a hundred

species of scale mosses indigenous to Great Britain and Ireland, some of which are so small as to be scarcely visible and others much larger than any of the true mosses. With the exception of a few prominent species, which are found in every moist wood and on every shady rock, they are somewhat local and limited in their distribution, many of them being remarkably rare and confined to remote and isolated localities. The greatest number of species occurs in the tropics; and nowhere do they luxuriate so much as in the dark woods and mountain ravines of New Zealand. Some of them grow in the bleakest spots in the world, and are to be found even at a higher altitude than the urn-mosses on the great mountain ranges of the globe. They form the faintest tint of green on the edges of glaciers and on the bare, storm-seamed ridges of the Alps and Andes, where not a tuft of moss or a trace of other vegetation can be seen; and this almost imperceptible film of verdure, when cleansed from the earth and moistened with water, presents under the microscope the most beautiful appearance.

The peculiarities of these plants are so remarkable and interesting that they deserve more than a passing notice. As a rule, to which, however, there are a good many exceptions, they do not grow upright in tufts like the mosses, but have a flat, creeping, lichen-like habit, spreading over rocks and trees in closely applied circles which radiate from a common centre. The whole typical plant is like a series or necklace of roundish, flat, imbricated scales, several of which branch from a common point in the

middle. The leaves, unlike those of the mosses, are entirely destitute of a central nerve, for what is called the nervure in the membranous or leafy species is nothing more than the stalk itself on the edges of which the leaves are fastened together in such a manner as to form apparently a continuous whole.

The Hepaticæ, or scale-mosses, may be divided into two groups, consisting of those species in which the vegetation is frondose, that is, in which leaf and stem are confounded, and of those in which the vegetation is foliaceous, that is, in which leaves and stem are distinct.

The most interesting of all the frondose group of scale-mosses is the common *Marchantia* or Liverwort (*Marchantia polymorpha*). It is very common, creeping in large, dark-green patches over rocks in very moist and shady situations, such as the banks of a densely wooded stream in a deep, narrow glen, or the sides of rivers and fountains. It may often be seen also on the moist walls of hothouses and in the pots and tubs. It adheres closely to rocks, which it sometimes completely covers with its imbricated fronds by the numerous white, downy radicles with which the under surface is covered.

The second or foliaceous group of scale-mosses, in which the leaves and stem are distinct, is called *Jungermannia*, and contains by far the largest number of species and the richest variety of form and color. On either side of the thread-like stem arise in a more or less oblique position the membranous overlapping leaves; while the fruit-vessel springs from the end of the stem, and is produced upon little

silvery foot-stalks. It bursts into four valves, and when fully expanded spreads out into the form of a cross. There is a class of plants whose external appearance and mode of growth would indicate that they belong to the tribe under review, but whose structure and functions are so different that they are commonly supposed to bear a closer analogy to the ferns. They occupy an intermediate position, and form a connecting link between ferns and mosses; I allude to the Lycopods, or club-mosses. They are usually found in bleak, bare, exposed situations in all parts of the world, and sometimes attain a large size; forsaking the creeping habit peculiar to the family, and becoming slightly arborescent in tropical countries, particularly New Zealand, rivaling in rank luxuriance the smaller shrubs of the forest.

The club-mosses are all very graceful and beautiful plants. The Spanish moss (*Lycopodium denticulatum*) is a great ornament to conservatories and hothouses, where it conceals with its luxuriant drapery the mould in the pots, and keeps the roots of the plants moist. Nothing can be lovelier or more elegant than a basket of orchids in full flower, with clusters of this moss in careless grace from its sides. Lycopods may be said to present the highest type of cryptogamic vegetation, the highest limit capable of being reached by flowerless plants.

The first pages of the earth's history reveal to us very extraordinary facts with relation to members and allies of the moss tribe. The club-mosses, in particular, at a former period, seem to have played

a more important part, or to have found conditions more suitable to their luxuriant development than is the case at the present day. The two or three hundred species at present existing are the mere remnant of a once magnificent group. Some of them are stated to have formed lofty trees eighty feet high, with a proportionate diameter of trunk. They are among the most ancient of all plants. The oldest land-plant yet known is supposed to be a species of lycopodium closely resembling the common species of the moors. In the upper beds of the Upper Silurian rocks they are almost the only terrestrial plants yet found. In the lower Old Red Sandstone they also abounded; while they occupied a considerable space in the Oolite vegetation. But it is in the Coal-measures that they seem to have attained their utmost size and luxuriance, *sigillaria*, *lepidodendron*, etc., being now considered by competent botanists to be highly developed lycopodia. Along with ferns they covered the whole earth from Melville Island in the Arctic regions to the Ultima Thule of the Southern Ocean, with rank majestic forests of a uniform dull, green hue.

EUROPEAN SEA-WEEDS

—P. MARTIN DUNCAN

THE zones of life are (1) the littoral zone, or tract between tide-marks; (2) the laminarian zone, from low water to fifteen fathoms; (3) the coralline zone, from low water to fifteen fathoms. Then come other zones leading to the great depths.

The broad-leaved tangles live in the laminarian zone, and it is called so from their Latin name, and therefore they limit the plants and animals of the shore, seaward.

It has been noticed that the animals and plants of the shores of our coasts are not the same everywhere, and that in certain parts some peculiar kinds are to be found. This is produced by climate, the nature of the sediment on the shore, the geological nature of the coast-line and inland parts, and the mineralogy of the district. And with regard to this last, it may be noticed, that where the rocks contain lime, or limestone and chalk, there certain shell-fish and corallines abound; but where this mineral does not exist, there they are comparatively or entirely absent. The British Islands, extending to the north and south, and being washed by the North Sea, the Atlantic, the German Ocean, and the Channel seas, come within the limits of certain natural history provinces. One is called the Boreal, and it extends across the Atlantic from Nova Scotia and Massachusetts to Ireland, the Faroe Islands, and Shetland Islands, and along the coast of Norway. That is to say, there are marine animals and plants which are found on the American, Irish, Scottish, and Norwegian shores, and which are either of the same kind or species, or of the same genus or group.

The next province is the Celtic, and it includes the coasts of England, Scotland, Denmark, southern Sweden, and the Baltic, and all these places have animals of the shore and other zones in common. The Channel Islands and parts of British south coasts

come within range of another province, called the Lusitanian, which is that of the west coasts of France, Spain, and of the islands off the coast of Africa. The Celtic province is that to which most of the British coasts belong; and it is a subject of great interest to know that many of the kinds of shelly mollusca, which are now living, lived in the last geological ages, and their remains are found fossil; so that the condition of the coast-lines and shores and a part of the assemblage of animals and plants now living on them have a remote ancestry.

It is by no means easy to say where the seashore begins landward. It may be limited by cliffs and mountain-ground, so that there is but little shore, and the tide-water then comes up the sides of the cliff; and it may reach for miles inland, among salt marshes, the ditches of which have salt water and marine animals and plants in them. Again, even when the shore is perfectly limited inland, there are proofs that the sea is near, long before it is reached. Trees usually get scarce, and often those which are seen are much gnarled and bent and covered with lichens. A new set of flowering plants is noticed, and the old favorites of the meadow and wood are absent; and grasses, reeds, rushes, and many singular plants straggle on the sand and pebbles, out of the range of the tide, but within that of the spray sent in by a high wind. Common observation has enabled even the most unscientific collectors of plants to recognize what may be called a maritime, coast, or shore flora, just as they can distinguish a marsh, mountain, or wood flora beyond the range of the sea. A flora is

the name for all the plants of a district, and it has been found that the seaside and seashore floras of these islands are very rich in kinds. Indeed, there are many little local floras included in the great seaside one, for the landscape, the nature of the rocks, and the vegetation of the shore, differ greatly in different parts. Each particular landscape by the sea, and every kind of soil there, has its little set of peculiar plants, some liking limestone, others clay, many rejoicing in sand, and some even finding nourishment among the highest pebbles.

Hence, on walking round British coasts, the plants, as a whole, will differ from those found inland, and at every turn or change of rock and scenery new kinds appear. But many of the inland plants do go down far to the seaside, and the art of gardening and all sorts of accidents have dispersed many plants which originally were not dwellers near the sea; and, on the contrary, they have also removed seaside plants, like sea-kale and asparagus, inland and into our gardens. In many places, however, and where the sea comes up very close, the inland plants are not found. There is a very remarkable thing about this seashore and seaside flora, and it is this, that nearly all the important groups, families, or genera of inland plants have a kind or two in it, and that there are few extraordinary novelties which would enable us to say that such a set of plants was destined for the seaside. Thus the pod-bearing order, which contains the pea, bean, clover, and such plants, has many species which are only found near the sea. The toothed medick (*Medicago denticulatus*), and the common melilot, love

sand and gravel near the sea; the star clover lives on a shingly beach near Shoreham; while two kinds of the genus *lotus* live on dry places, two being found near the sea in Devon and Cornwall. There is a vetch, with a pale purple flower, on the pebbly beach of Weymouth, and another of a sulphur-color likes such situations. Even the poppy order has a kind with large golden-yellow flowers, with seed-cases from 6 to 12 inches long, living on sandy seashores; and this "horned poppy" has a very interesting companion, for a poppy with a bluish-white flower with a violet spot lives in the fens and on sandy ground near the sea, and it is the kind which yields opium. The cruciferous plants, of which the wall-flower, the rocket, cabbage, mustard, etc., are examples, are well and interestingly represented at the sea. There is a sea-stock living on the sandy seacoasts of Wales, Cornwall, and Jersey. The wild cabbage, the parent of all domestic cabbages, lives on cliffs by the sea; a wild mustard is at St. Aubin's Bay, Jersey; a white draba, not very unlike the common whitlow grass, is on sandhills by the sea in Islay. The scurvy grasses are all found on seashores, and constitute a shore group. Finally, there are the purple sea-rocket and sea-kale, loving sandy shores, and there is a rare wild sea-radish. Among other well-known inland orders of plants, such as the violets, there is a rare one with its flowers wholly yellow, or yellow with the upper part purple, living on sands by the sea. Of another order, the tamarisk may be seen close to the waves on the Essex coast; even the pink tribe has a sea bladder-campion, an alsine, and a ce-

rastium. Again, the tree mallow lives on rocks by the sea. The rose tribe are certainly not lovers of the seashore, but there is one kind belonging to the whitethorn tribe (*Cotoneaster*) which ornaments the rocks of the Great Orme's Head, in Carnarvonshire; and a solitary kind of the thick-leaved plants, a sedum, lives there also, loving the limestone soil. The *Corrigiola littoralis* of the southwest of England has white-stalked flowers. The sea-holly, with its blue flowers in a head or umbel, lives on sandy seashores; the wild fennel, the Scottish lovage, and the fleshy-leaved, whitish-flowered samphire love rocks by the sea. The sea-carrot lives on the southwestern coasts.

The red valerian is found on chalk cliffs; but no other of its tribe, or of the teasels or scabious set, is found particularly as a seashore plant. Both the composite orders, of which the daisy and the asters are examples, and which form so large a part of the inland flora, have many seashore species. Thus, there is the golden samphire, allied to the elecampane plant, the sea-diotis, the sea-feverfew, and the sea-wormwood. There is, or was, a wild cineraria on the rocks of Holyhead, and there is a thistle with pink flowers which loves sandy places by the sea. The least lettuce likes chalky places. One of the centaury kinds lives on sandy seashores, and there is a seaside bindweed with very handsome pink flowers with yellow bands. One of the bugloss tribe lives on northern seashores, and there is a curious great snapdragon which is to be found about cliffs overhanging the sea. The primroses and pimpernels are not in-

habitants of the seashore, but two sets of plants, called glaux and samolus, belonging to their order, frequent the shore and salt marshes. Then there is the sea-lavender tribe with four kinds, all living in England, or Ireland, on rocky shores and salt marshes; and the thrift plant likes the shore as well as the mountain top, a distribution which is noticed also in the sea-plantain. Many of the spinach tribe, such as the glass worts, the sea-beet, the salsolas, and the sea-purslane, inhabit the shores, and some of them were formerly used in the preparation of barilla. Such a common thing as the dock could hardly be found away from the sea, and there is really a sea-dock found on the marshland; and the Channel Islands have a sea-snake-weed. A thorny shrub with lancet-shaped sliveryleaves, and attaining the length of from four to six feet, frequents sandy spots and cliffs, on the southeast and east coasts, and is called the sea-buckthorn. There is also a sea-spurge. The wild asparagus, with a stem not one-third of the height of the cultivated kind, but the true parent of all asparagus, is a rare plant, but it has been found at Kynance Cove, Cornwall, Callar Point, Pembroke, and at Gosford Links in Scotland. Another important plant, the onion, has its representatives on the rocks of Guernsey, and another called chives is a Cornish cliff seaside dweller. The rushes have several kinds on salt marshes and shores, and there is a plant called the zostera, with long leaves, which flourishes under water on many parts of the eastern coast. Belonging to the same botanical order is the *Ruppia maritima*, found at Newhaven and Guernsey.

The sea-sedges, a cat's-tail grass, a fox-tail grass, an agrostis, a sea reed, and a common poa grass, with a root-like bulb, are familiar objects on swampy sea-shores; and a whole group of grass plants belonging to a tribe called *Sclerochloa* inhabit sandy seashores. The couch-grass dwells there also; and the list may be closed by noticing the sea-barley, a tiny plant, but loving sandy pastures near the sea. And among the ferns a spleenwort lives on rocks over the sea.

These are all plants of a complicated structure, and produce seed. But those about to be noticed are the true sea-weeds, which have a simple construction and belong to the cellular plants.

Where the land plant ends, the sea-weed begins, and as some flowering plants or grasses come close to the edge of the high spring tide, so some sea-weeds choose that position, and appear to like a dry time for a while, and a refreshing return of the salt water at distant intervals.

One of these sea-weeds abounds on muddy sea-shores, at the entrance of rivers and marshes, and positively adheres to the roots of flowering plants. North Wales, Shoreham, the Essex coast, and the Shannon are places where it is found in abundance. Moreover, like most of the sea-weeds, it has a wide distribution, for it is found on the Atlantic shores of Europe as far south as Spain. The plant is from 2 to 4 inches high, and consists of stems about as thick as stout bristles. They branch and give off side-twigs, like the veins of leaves in shape, and each ends in a curious curl. The whole plant is limp, and easily squeezed flat. It is of a dull purple color,

and from its curl endings has received a Greek name, "bostrukos," a ringlet. Old authors called it "Amphibia," from its locality, which has just been noticed; and it is remarkable, because most of the other red or reddish sea-weeds of its group live in deep water.

Another sea-weed which lives at the very top of high-water mark, but which is also found on the shores down to low-water mark, and still lower, is a fine plant often growing a foot in height. Its stem is round and solid, and branched in what is called a pinnate manner, like a mimosa leaf. It is yellow or livid green in color, and is very small and starved at high-water mark, but it grows larger and larger until well under the sea. One of the kind is found on loose stones, where a rill of pure fresh water runs into the sea. In Scotland it was formerly eaten under the name of pepper dulse; but better things are now to be had. It is named *Laurencia* after a French botanist.

A membrane-like sea-weed, which grows upward with swellings like a cactus which give it the appearance of a chain, is called the little chain sea opuntia (*Catenella Opuntia*). It is also a dweller on rocks, close up to high-tide mark, on our shores as far as the Orkneys.

Often at high-water mark, and on wood and stones down to half-tide level, there is a quantity of dark olive-green sea-weed, in small tufts, getting larger nearer the sea, which often looks dried up, shriveled, and crisp. It grows in tufts when the water goes off rapidly, and it evidently requires exposure to the air

for several hours in the day. Nearer the ever-rolling sea the plant grows larger. It is called the channeled fucus, and has an expanded part or root, and a stem which branches in twos, and ends in two long cones of softish stuff which contain the reproductive organs or spores, called receptacles. It belongs to the same group of sea-weeds as the commonest of all, or that which has air-bladders on it and which crackle and burst under the feet. A differently colored high-water-mark weed is found at Yarmouth, Bantry Bay, Torquay, and Sunderland on sand-covered rocks. It lies prostrate and is of a pale green color, forming masses or layers of excessively minute threads of vegetable tissue. It belongs to the genus *Codium*.

The sea-weeds called wracks or fucus are among the most common of the dark greenish-olive kinds, and one of them lives in a curious place on the shore. The stem or frond is from one to two feet long; there is a kind of midrib to it, besides the cones or receptacles, at the tip of each branch. It is common from Orkney to Cornwall in many places, and is found where a good deal of fresh water mixes with the sea, but it is not restricted to such peculiar positions, for some of the most vigorous plants live in salt water, and some very transparent and weak ones in brackish water. The common bladder fucus is found everywhere on rocks and stones and wood left exposed at low water, and on artificial quays in estuaries extending up rivers as far as the water is decidedly brackish. Even in salt water it is noticed to flourish. The plant or frond is in long, flat, thin branches with a midrib, on either side of which are the bladders, which

contain air. The branches end in thick gummy-feeling masses, which are turgid, rather pointed, and contain the spores. The color is olive and it is lighter in the younger parts. It is found along the shores of the Northern Atlantic, extending even to the tropics. It is used as manure, and also in forming kelp for the purposes of the manufacture of iodine. Cattle eat it in the winter, and of late it has been used in baths. A larger kind of fucus grows from high-tide mark to mid-tide level, and it has large swellings on its stem, and the branches, which come off in whorls, are distended, as it were. It is used in the kelp manufacture and for covering up oysters. The Scotch shore-men call it the sea-whistle, for boys make whistles out of the larger air-vessels.

The serrate fucus, so called from its saw-like edges, has no bladders, it clothes the rocks at half-tide level, is very common, and is found on the western shores.

On the rocky bottoms of submarine tide-pools, near low-water mark, all round the coasts of Scotland and England, is a weed with narrow fronds and pinnate ones of a lance-head shape, with spiny teeth on their edges. It is a clear olive-brown plant, and gets a verdigris tint when it is exposed. It is called the ligulate desmarestia.

Perhaps more beautiful, but not more interesting than these kinds of fucus, are the *ulvæ*, those broad, flat, wrinkled edged, green sea-weeds, looking like half-transparent membranes. One of them, the broad *ulva*, has a small disk by way of a root, and grows from six to twenty inches in length and from

three to twelve in breadth, in tufts of different shapes. It is very common on all shores, on rocks and stones between tide-marks, and extends downward to a depth of ten fathoms. It has a wonderful geographical distribution, for, with the exception of the coldest regions of the globe, it inhabits every shore. It used to be eaten under the title of oyster green, being prepared like laver; and the Icelanders used to, and perhaps may still, ascribe an anodyne virtue to it. They bind it on the forehead in fevers, writes a Scottish botanist.

The other *ulva*, which is nearly as common as this, is smaller, and grows in the form of an inflated bag, which opens and expands. It is of a very bright and yellowish green, and it is thinner and more delicate than the other kind. It is seldom seen except in spring or early summer, on rocks, stones, and shells between tide-marks, and it is generally distributed around British shores and those of Europe.

A very common green weed, found between tide-marks and also in ditches running into the sea, was supposed by its first describers to resemble an entrail or intestine; hence it has been called *Enteromorpha intestinalis*, from the Greek words *enteron*, entrail, and *morpha*, form. It grows from a few inches to a foot or more in length, and from a line to three or four inches in diameter. Seen where it is attached to a stone, it is like a tube, hollow, membrane-like, and green; but further out it is larger and swells out into an irregular bag, crisped and curled here and there. It is very common all over the world, and finds its way sometimes into fresh water. The Rev. J. Pol-

lexfen notices that it is prepared for culinary purposes by the Japanese for an ingredient in their soups.

The other common green *Enteromorpha* is called "the compressed." It is in the form of a branching green, delicate tube, flattened here and there; and it clothes rocks between tide-marks, being sometimes as fine as a hair. It gets narrower at its attachment and is broad at the ends. Near high-water mark it forms a short, shaggy pile of slender fronds spreading over rocks and stones, and most treacherous to the stepping of unwary feet, being most slippery. A little lower down, in the rock-pools, it is larger, tubular, branched, and thin near the root; and where fresh water runs in close to it, the fronds get larger, broader, and more inflated. Almost everything on floating timber or on stone is this kind of weed. From being more or less tubular, these *Enteromorphae* have a double green membrane. Now there is a beautiful ribbon-shaped *ulva* which has this double formation and which is found at half-tide level. It is long, even reaching to two feet, and is only half an inch to two inches broad. Very elegant and graceful are its tapering, curling, wrinkling, and plaiting of the edges; it is called *Ulva linza*, and is of a bright green color. Among the commonest of the small green sea-weeds are the *confervæ*, hairy-like green threads, which collect in layers and fleeces and cover much surface, or wave in the rock pools. One kind called the sandy *conferva* lives at half-tide level at Bantry Bay and also in Scotland at Appin. It forms fleeces a yard or more in extent, made up of thin

layers placed over each other, but so slightly connected that they may be separated like gauze, for some inches, without breaking. The hairs or filaments are five or six inches long and are rather rigid; they are very long-pointed, and consist of a delicate tube membrane which incloses a series of long cells. Another conferva, found attached to other sea-weeds at Bantry Bay, Berwick, Firth of Forth, and Torquay, has its filaments forming densely interwoven layers which cling over their supporting plant. It is of a dark green color. A third frequents salt pools by the edge of the sea and rocks at half-tide level. It is a very twisted thing, and forms crisped layers from a few inches to several feet thick, which closely adhere to the inequalities of the rock, or to the plants which grow on it. It is of a glossy brilliant green color, and is called the tortuous conferva.

There is a pretty green hair-like plant which branches and gives off branchlets on one side more than on the other. It comes from a little group of stems on a stone, and forms a small stunted but very elegant bush, three or four inches high. This cladophora lives in the purest and clearest sea-water only, and in rocky pools left by the tide near low-water mark. It is only got at low spring tides at Dingle and Dublin, and it evidently likes the cool sea water and darkness. A sea-weed called the Adherent Codium forms a velvet-like pile on the surface of rocks in the southwest of England near low-water mark, but it is rare. Sometimes the green velvet-looking film may be three feet across, and it consists of myriads of short cylindrical filaments with simple club-

shaped hairs on them. It is soft and gelatinous, sticks to paper, and appears to grow slowly. Another codium, called the amphibious, has been mentioned already. It occupies a different position on the shore to the other. It frequents turf banks on the west of Ireland, in County Galway, where the bog touches the shore. It is a very mesh of entangled filaments, and it dries up to almost nothing in dry weather, and increases and grows again on the coming of the welcome tide, spray, or rain. There is also a large codium with branches, which looks like a sponge.

Barnacles and shells, living at low-water mark, in exposed situations on the western shores of Scotland and Ireland, Falmouth, and the Land's End, have a weed upon them of a purplish-brown color like a "crop of threads" (*Nemalion*) of from three to ten inches long. They are slender, solid, and divide in twos from a little expanded base. In some places it chooses particular positions, and in our Irish localities it grows in shallow pools on the granite rocks, and nowhere else.

A common weed, sometimes twenty inches in length, varies from pale yellow in shallow water to dark purple in deeper places; it lives at half-tide level, and is made up of tubular fronds filled with watery gelatine. Its tube swells, here and there, and bends at the end in a curious manner. It is called, after a French naturalist, *Dumontia*. Another weed with a cylindrical stem has many branches, and has swellings at their origin like so many knots. These are air-vessels and help to support the plant, which is rather leathery. It is found on the English and

Irish shores, and is called the bladder chain-weed (*Cystoseira*). But the most elegant of the weeds with air-bladders is called the sea oak (*Halidrys*) and it is found commonly on rocks and stones in the sea, below half-tide level. The fronds are from one to four feet in length, and the branches bear numerous long pods with compartments in them, the whole looking like a mustard-pod, and these are the air-chambers.

The waving, slender, long weed, so slimy to the touch, and which is so abundant on all British shores—the dread of the bather when it forms submarine meadows, over mud flats—is called the cord-weed (*Corda filum*). It is sometimes forty feet, but usually from one to twenty feet in length, and is not twice as thick as a bristle where it starts from a stone, tapering and clothed with delicate hair, getting wider in the middle, and slender and hairy at the top.

There are some remarkable sea-weeds, which certainly do not look like things belonging to the sea, but rather to the land, where lichens and fungi live on stones and trees. One often is called *rivularia*, and is found on rocks, at half-tide level, on the southern shores of England, and in the south and west of Ireland. It incrusts the rocks, rising in short lobes, and it feels fleshy and firm. It begins with a globe-shaped substance, which sends forth ragged-looking pieces; and although it is so dense, the surface is covered with a close pile of exquisite filaments. Many a dark rock, otherwise perfectly barren at the end of summer, is clothed with the bright green patches of this singular weed. Another of

these incrusting things is often as round as a half-crown, and looks like a lichen. It is leathery, and gets ragged and warty with age, and is of a coffee-brown color. It is called *Ralfsia*, after Mr. Ralf. A third kind looks like a flat thin clot or stain of blood; hence its name *cruoria*, from "cruor," blood. It forms a scum on the smooth, exposed rocks between tide-marks, and is especially abundant in the west of Ireland and Jersey. The patches are from one to three inches in diameter, and their edges are very clearly curved; they are brown and red, and the hairs or filaments of which they are composed are purplish red. It can be removed in flakes with a knife.

Many sea-weeds are found upon others; and indeed some of the most beautiful kinds are thus parasitic upon larger ones. An instance of this occurs to one of the humble crust-like weeds which is found on pebbles at half-tide mark. So small is the parasite that a slight magnifying power is required to make it distinct, and then it is found to be made up of thousands of minute forked threads, each of which consists of several long cells, one placed before the other, and some of the cells are large and egg-shaped, and contain the seeds or spores. It is called the *Myrionema*, from two Greek words which mean numberless thread.

The next great group of sea-weeds to be noticed on the shore has many more kinds below low-water mark, where they are never uncovered, than above. They are the great dark, olive-colored, ribbon-shaped, wavy-edged weeds, which have a tough skin and roots, which adhere to rocks, and which are

called tangles and laminariæ by botanists. Their proper position, as a rule, is not on the shore, for they almost characterize a particular zone of depth; but there are kinds to be met with on rocks and timber, close to the low-water mark, and on the shore. Some of them are very remarkable when they are placed, as they are in the north of England, on the sea-beaten parts of white or gray rocks. They then often form a dense layer—a sort of black, moving fringe, which is sometimes uncovered. Most of them flourish in the most boisterous seas, and it would appear that those which may, with some reason, be called shore-plants, because they are close to low-water mark, and now and then uncovered, are smaller and more delicate. Thus one kind, which has been called the weak, or the papery tangle (*Laminaria fascia*), has a stem not bigger than a bristle, which gradually widens into a frond about twelve inches long and two broad. It is greenish or brownish-olive in color, and is very fragile. It has the remarkable geographical distribution which is very common to all those weeds living on the brink of the sea, for it is found as far off as the Falkland Islands. On British coasts it covers sandy rocks and stones near low-water mark, and is to be found in the north of Ireland, the western islands of Scotland, and the southwest of England.

Another kind fringes precipitous rocks at low-water mark, and is abundant on the shores of Scotland and of the north and west of Ireland, the west and southwest coasts of England, and the northeast coast. Mr. Harvey notices it as one of the kind lux-

uriating in a furious sea, although its frond can be readily torn with the hand. It has a stem as thick as a quill, and a root of many branching fibres. The frond, or ribbon-shaped leaf, is from three to twenty feet in length, and only grows three to eight inches broad. It has a midrib running down its whole length, and the following peculiarities: there are many little leaflets on either side of the stem before it merges into the broad frond, and the surface is perforated with small pores, out of which come tufts of shred-like fibres. It seems to be an everlasting weed, and the first growth in the frond occurs from the stem.

The new parts are lighter colored than the old, and after a while intersection takes place, where the new part joins the old, and the old leaf falls. This plant, from the side leaves giving it a winged appearance, is called the *Alaria* (from *ala*, a wing), and it is eaten in some parts of Scotland and Ireland. The midrib is the delicacy, but it is very insipid. The Scottish name is *badderlocks*, or *henware*, and the Irish, *murlins*.

A most graceful and delicate tangle is to be found on the south and east coasts of England, all round Scotland, and at Bantry Bay, Howth, Balbriggan, and Kingston, in Ireland, on rocks and stones in pools left by the tide. When fresh, it is a clear brown-olive in color, and it changes to green when dry or when placed in fresh water. The leaf comes from a stalked root, tapers to the end, is frilled at the sides, and may be from six inches to three or more feet in length, and from one to six inches broad.

It is thin, but is traversed by a double layer of large air-cells.

There is a large tangle which goes by the name of furbelows; and when spread out on the shore may make a circle of fronds twelve feet in diameter. It is a clear brown-olive in color, and the root gives rise to a stem with large hollow knobs on it. The leaf is oblong, and is deeply split into many parts. The plant grows on rocks at low-water mark, and is abundant.

But the commonest of all these tangles, with its long stem and branching roots, and beautiful, slippery, crumpled leaf, forms a belt, about low-water mark, round rocky shores, where its long, ribbon-like fronds wave gracefully in the water. When it is in deeper water it is much larger, and is then called the broad-leaved tangle. The great tangles which are employed to form kelp are not shore plants, but live covered with water.

The gems of the seashore are, however, not the olive and green weeds, but the red kinds, and they abound. There is a very large and handsome one, which is rare in deep, shady pools at extreme low-water mark, but which is often washed up in storms, about the southwest coast of England, Bantry Bay, Antrim, Down, and Orkney. It is somewhat kidney-shaped, in the outlines of the large blood-red fronds, and has a stout, round stem. It is made up of three layers, and some plants are male, and others are female. This plant is called *Kalymenia*, from the Greek words that mean beautiful and membrane. Another kind of the *Kalymenia*, found

at Falmouth, Plymouth, and Bantry Bay, is something like a short, broad tangle with crisped leaves in shape. It is red, and the root is a disk, and the fronds are about a foot in length. It is found on rocks and stones, within tide-marks, in land-locked bays. It is very thin and delicate, and may be compared with a totally different-feeling red seaweed, which has flat fronds of irregular shape, fringed with little leaflets, the whole being half-gristly to the touch, and of a dull purplish color. It is common on the shores of the south and west of Ireland and Jersey. The root is very fibrous, and altogether it is a most peculiar weed. There is another of these leathery weeds which grows to some size, and has well-grown leaflets on its edges, besides large circular markings on its purple surface, which is pretty common everywhere. They belong to the genus *Rhodymenia*, so called from the Greek words red and membrane.

The last kind is the dulse of the Scotch, and the dillisk of the Irish. Mr. Harvey thus notices its edible peculiarities: "In Ireland and Scotland this plant is much used by the poor as a relish for their food. It is commonly dried, in its unwashed state, and eaten raw, the flavor being brought out by long chewing. On many parts of the west of England it forms the only addition to potatoes in the meals of the poorest class. The variety which grows on mussel shells between tide-marks is preferred, being less tough than other forms, and the minute mussel-shells and other small shell-fish which adhere to its folds are nowise unpleasing to the consumers of this sim-

ple luxury, who rather seem to enjoy the additional *gout* imparted by the crunched mussels. In the Mediterranean this plant is used in a cooked form, entering into ragouts and made dishes; and it formed a chief ingredient in one of the soups recommended under the name of St. Patrick's Soup by M. Soyer to the starving Irish peasantry." It should be noticed that Dr. Harvey was keeper of the herbarium in the University of Dublin, and that he wrote in 1846.

Another dark-red sea-weed, which is very iridescent, when waving under water at low spring tides, is also said to be eaten in Cornwall, but, Harvey says, more by women than men. It is called the Edible *Iridæa* from its rainbow colors, is about six inches in length, is gristly to the touch, and is rather like a battledore in shape.

The supposed luxury which is served at the tables of many, and which is called laver in England, and sloke, sloak, or sloukawn in Ireland, comes from some sea-weeds which are delicately membranaceous, flat, and more or less purple. The color gives the name *Porphyra*, from the Greek word "*porphuros*," purple. One kind is something like a large, crumpled lettuce-leaf in shape, without the veins and stalk, and the other, which is the commonest, has a long frond like a tangle, of one or two feet long; but there is no long stalk. The edges are crisped, and the end of the frond is rather sharp and long. It is very thin, glossy, and more or less of a vivid purple. It is abundant on rocks and stones between tide-marks on our British shores, and is an annual.

There is a handsome sea-weed called *Nitophyllum*

punctatum, "a shining leaf." It is of a rose-red color, and its membranaceous frond has its edge cleft; it is veinless, or has irregular veins toward its base. The thin expansion is very delicate, and is characterized by the want of "nervures" or veins, and the presence of spots or tubercles immersed in it. These are large, oblong, and very general, and contain the spores. In other plants of the same kind the spots contain tetraspores. The root is from a small disk, and the fronds grow in small tufts from twelve to twenty inches in length. They are attached to other weeds at low-water mark; and are found on rocks down to fifteen fathoms. It is very abundant on the coast of Antrim, and all round the British coasts.

A rose-red filamentous sea-weed being from two to six inches in height, with the stems not much thicker than bristles, their fronds being long, is found on rocks near low-water mark, and generally in deep pools from Orkney to Cornwall. It is called *Griffithsia Corallina*.

Other kinds of *Rhodymenia* are common on rocks and stones, or on the stems of the tangles, near the very verge of low-water, or higher up. One found in the first situation is most common in the south-west of England, but is found everywhere on the British shores. It has a little disk for a root, and a long, slender stem, rather round near the root and flat above, where it gradually expands into a red membrane in the shape of a fan. But it is not whole, for it rather resembles a skeleton of a fan with notches at the edges, a dark spot being at their

ends. The whole may be four inches long. The other kind is purplish, and the stem has branches, each of which ends in a ragged fan. It has little knobs on the side of the stem and on the membranous parts which bear the spores. It is sometimes called by another generic name, that of leaf-bearer, or *Phyllophora*.

A rose-red sea-weed which has a midrib along all its thin branching fronds, and which is like a flat miniature bushy tree, is common all round British coasts, between tide-marks and more deeply. The tips of the fronds have little bodies on them which are whiter than the rest, and which contain peculiar spores, and there are also little knobs or tubercles which are attached to the midrib, and these contain another kind of spore. It belongs to a number of sea-weeds which have been named *Delesseria*, after Baron Delessert, a former distinguished botanist. Another, which is called *Delesseria sanguinea*, from its blood-red, or rather rose-red color, has a frond like a laurel-leaf, but it is crumpled at the edges. It is thin, has a midrib, and several spring from a stalk. Little fronds come from the midrib, in the middle of the larger fronds. It is one of the many weeds that fruit in winter time, and it is to be found in deep rock-pools, between tide-marks, and generally at the shady side of the pool under projecting ledges of rock. It is a great favorite, and grows to a considerable size, the fronds reaching sometimes ten inches in length.

Perhaps the most beautiful of the red weeds is found on rocks, and on other sea-weeds, at low-water

mark. It resembles a number of skeleton leaves on a stem dyed a fine red, for the frond is not a membrane, but a number of branching threads or hairs, and it arises from a stem. It is from six to eight inches in length, and is named *Dasya*, from *dasy*, the Greek for hairy. It is much used for ornamental purposes in the collections of sea-weeds.

One of these dissected skeleton-leaved sea-weeds is found on rocks and on other sea-weeds, near low-water mark around British coasts. It is a tender and soft plant of a fine carmine color, and it arises from a stem, which, after growing for a while, branches in twos. Then side-twigs come off opposite each other, and one on either side of the stems and branches, and numerous hairy-looking projections arise from the upper edge of each of the twigs. Each hairy process has others on one side of it, and some of them bear little bulbs which contain the spores. It is singularly regular in its growth, and, as it is small, it looks well under low magnifying power. It is a pretty shrub-like thing, and hence its name beautiful little shrub, or *Callithamnion*. Another *Callithamnion* is that branching weed which is seen waving under water upon the stems and fronds of the tangle. It is a robust and shrubby-looking weed, which, even when dry, retains some of its elegance of form. It is of a brownish-red color, and when fresh water is added it becomes of a brilliant orange tint, and gives out a rose-colored powder.

One of the many instances in which one kind of sea-weed is much more luxurious in growth on the Irish than on the British shore is noticed in the case

of a beautiful skeleton-looking, crisp, red weed called "Wrangelia," after a Swedish naturalist. Its fine stem has little whorls of fibrils one above the other, so that it presents a most strange resemblance to the common horsetails of our marsh ground. Branches come off from the whorls, which, horsetail fashion, have their bracelets on successive whorls. It has a root of fibres, and a good-sized specimen would cover a quarto page of paper. They are found on the steep sides of pools near low-water mark, under the shade of other sea-weeds, and they are to be picked on the south of England, Jersey, Belfast, and the west of Ireland.

The braided-hair weed, *Plocamium*, from *plokamos*, braided hair, is the pinky-red, ribless, much-branched, rather gristly weed, which, from its elegant arborescence and beautiful color, is an especial favorite with the workers in ornamental seaweed decorations. It is cast up in quantities on the British shores; but, as a rule, it lives beyond the shore, that is to say, below low-tide level. Another equally common weed has a slightly darker red color, and its frond is horny, flat, branching in twos, and with little fronds on the edges. It is found from the very verge of high water to the extreme of low water, fringing the margins of the rock-pools, and is very common. From its hard condition and horny nature it has been called *Gelidium*, from *gelu*, frost. The beautiful red weed, whose resemblance to a great branching tree pressed flat is so great, and which bears thousands of little berry-looking knobs on short stalks, on the sides of its fronds, is called *Sphærococcus*, or

globe-fruit or berry. It is not known on the eastern coast of Britain, but is common on the Irish shores at extreme low-water mark. Another red weed, with a dull purple color, has a frond of from six inches to two feet in length, and every minute ramification of its skeleton-leaved frond has one or more berry-shaped swellings. It is common all round the coast within tide-marks, and has been called after a genus of mosses, *Hypnæa*.

The last kinds of filamentous, or skeleton-leaved red weeds, to be noticed, are remarkable for their tufty nature, their spreading out in water and showing tree-like branching from a stem, which, when magnified, is seen to be made up of many long cells placed side by side. Some live between tides on rocks, and others at the edge of low tide, but the most interesting are parasitic upon other weeds. From their many-tubed nature they are called *Polysiphonia*. The parasitic kind (so named) is rather rare, and settles on some of the calcareous weeds. The lanceolate kind is found on the stems and fronds of the tangle; and a dark red species, called *Formosa*, is found near low-water mark. Brodie's *Polysiphonia* is known by the little tufts of branches which come from the main branches, and it has a good stem. It is found on corallines and on rocks.

The fibrous *Polysiphonia* has tufts at the end of its branches, and is found on mussel-shells; and the violet kind is brownish-red or purple, has a small root-like disk, and fronds which are from six to ten inches in length. It is feathery and much branched.

It has been noticed that some sea-weeds are

parasitic, or live on others, fixed certainly, but whether they get any nourishment through their roots is doubtful. One of these is very common on Fuci, the bladder one especially; and it occurs as dense little tufts on the leaves. These, when examined, are found to be made up of long, flaccid, olive-colored hair-like filaments, about an inch in length. They rise from a little hard spot, and form a tuft with a broad circular outline. They belong to a genus called *Elachista*, from the Greek word for "the least." The hairy *Ceramium* is a tufty weed, which is sometimes parasitic and sometimes not. It has a very peculiar shape, being made up of filaments placed side by side in great numbers, but they branch and rebranch, have little whorls of minute prickles along them, and the ends curl gracefully.

Among the more remarkable sea-weeds is the Carrageen, or Irish moss. It is a very variable plant in its color and shape, and it may be a yellowish-green, a livid purple, or of a brownish tint, and it may be in the shape of a wrinkled, crumpled fern, or of a bush. It has a root-stem, reaches a foot in height, and the largest are found in estuaries where mud comes down with fresh water. The weed is found abundantly on the shores of Great Britain, and formerly was used in the place of isinglass for making blanc-mange, an edible which has degenerated with the progress of imitative culinary art. It was a fashionable remedy for consumption, and many of the peasantry of the west coast of Ireland used to collect it.

A most extraordinary fan-shaped sea-weed has a

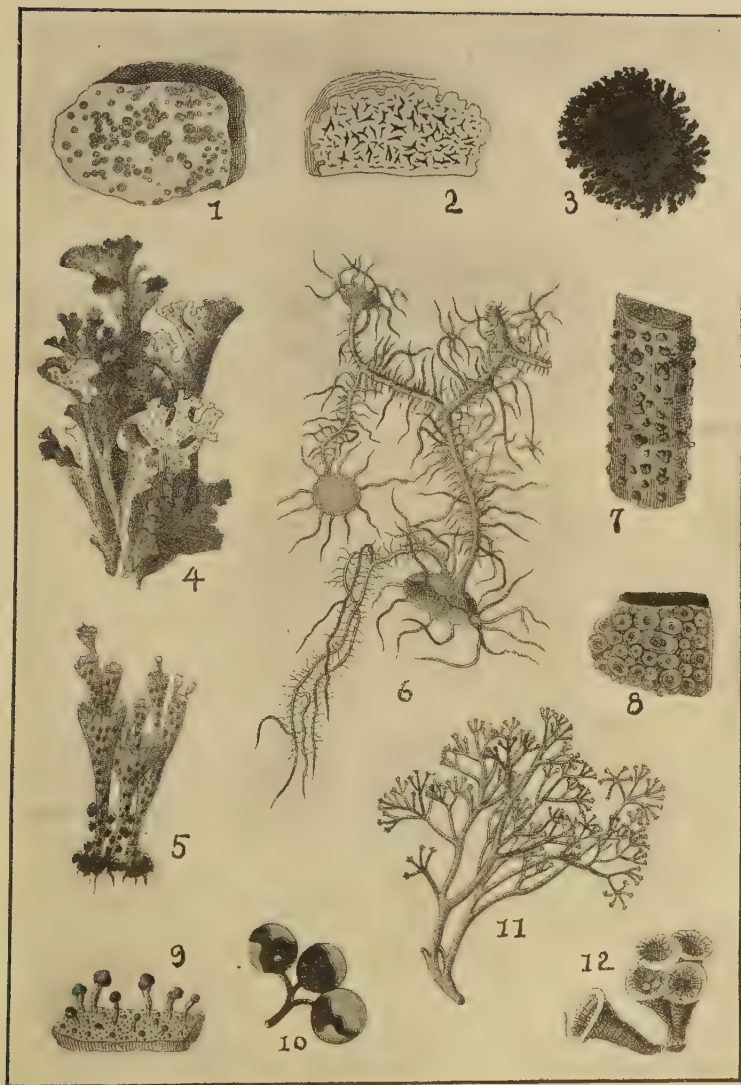
root covered with woolly filaments and fronds, from two to five inches in length, wide at the base, and expanding in almost perfect half-circles. The frond is curved, marked across, and has a disposition to form funnel-shaped pieces. A fringe of orange-colored filaments is on the markings, and at the edge, which is often strongly rolled inward. The outer surface is covered with a kind of whitish powder. The general color is yellow and olive, with a dash of red. This peacock-tail weed is found on rocks in shallow pools, on parts of the south of England coast, and is abundant at Torquay. It is remarkable for being an extension, northward, of a common tropical sea-weed.

A very common plant is to be found, either growing in little tufts on the rocks at low-tide mark, or as a waif cast up by the waves, in bunches, near where the coast contains rocks or earths which have carbonate of lime in them. It is also a dweller in deeper water on the floor of the sea, and oftentimes it may be seen waving lightly in a rock-pool; but it does not look like a plant. There are no leafy fronds, and it does not resemble any other common sea-weed in outside appearance. It has a stony look, and is hard to the touch; it will stand a pinch, and although it may break into separate pieces it can hardly be crushed by the finger and thumb. Usually, as seen by most people, it is of a glistening white color, with some purple about it, and is made up of a number of joints. The coralline, for so it is called, has a sort of broad crust where it adheres to the rock, which gives out a stem. This stem is slen-

der, and is made up of many pieces, placed one before the other, narrow where they join, and rather swollen in the middle or at the end. Other pieces, usually two, come off from the piece at the joint, and there may be hundreds of them or only a few. The end of the plant is made up of tufts of pieces, some of which have a little hole in the end, as if there were a hollow place. Now, if the spots where the pieces join be looked at carefully, there appears to be something like very thin threads uniting one piece to another, and they are not covered, as all the rest is, with the glistening white stuff, which feels gritty between the teeth. These corallines, if placed in vinegar, begin to bubble as if they were made up of chalk, and their outsides are composed of a mineral called carbonate of lime. After a while the vinegar dissolves all the hard white part, and leaves the threads, which are now seen to run the whole length of the coralline. These threads are portions of vegetable fibre, and constitute the inside stem as it were, which is surrounded by a sort of bark of carbonate of lime.

But this is only a popular manner of explaining, for if more care is taken, it will be found that, although some fibres run through more than one joint, others, when they are in the midst of a piece, turn outward from the middle, and come near the surface where the carbonate of lime is. There they end in delicate bags or cells in rows, the last of which is quite at the surface; so that the outside of the pieces is made up of a mass of these small microscopic cells, and the rest of the long fibres. The older the plant,

the more carbonate of lime is there in this mass of cells; but in very young plants, in the spring of the year, there is but little of the mineral, and they may sometimes be got quite soft. They are then short little stumps fixed on to the expanded root, which sticks on to stones, and they are not white, but of a beautiful claret or port-wine color, the joints, where the fibres are, being greenish or without color. This immature plant can be examined with the microscope, and then the secret of how the carbonate of lime is put in is divulged. First, it appears that any part of the young coralline which is growing, does not have any of the opaque mineral in it, and that the fibres never have it in them, nor has a very delicate skin which covers the whole, and which is very difficult to get a sight of, for it is easily washed off. By putting a young piece in weak acid, bubbles come out, and every now and then one blows up this exquisitely thin pavement-looking film from off the surface. It is then seen to be made up of flat cells, placed side by side, and colorless. This is the important tissue by which the plant lives, for it exists long after all within is hard. It is always growing and being repaired; and in the tropics, where the water is warm, the little cells of it are covered with very long hairs, and, indeed, they may sometimes be traced in English specimens. Leaving these outside cells and the membrane for a while, it is necessary to consider those beneath, and which are more or less connected with the long fibres of the joints. A row of these more deeply seated cells is on the outside, just beneath the membrane, and other rows are



Lichens and Small Fungi

1, Lecanora; 2, Opeographa; 3, Parmelia; 4, Cetraria Islandica; 5, 11, Cladonia; 6, Usnea Barbata; 7, Red Wart Fungus; 8, Pertusaria; 9, Bæomysces; 10, Erysiphe; 12, Cyanthus

deeper and deeper still, until the ends of the fibres are seen to end, as it were, in contact with the innermost. The outer row of all these is of a pale green color, and gradually the port-wine tint comes with depth from the edge. Each of the cells of these rows is not quite covered with the hard mineral, and they communicate their fluid contents to another; and it is found that it is between the cells that the carbonate of lime is deposited, and which can be dissolved out by vinegar. As soon as a set of cells has done growing, the mineral is deposited, invests, and comes outside them, until it invades the delicate membranes of their bag as well. How does this plant live? and where does it get its lime from? It does not absorb anything by its root, for it is placed on a stone, but all nourishment enters by the thin outside layer.

In all sea-water there is some organic stuff or sea soup, the result of the decomposition of tiny things, and there is some air in the water which contains oxygen and nitrogen and carbonic acid. Under the influence of life, the organic stuff is absorbed by the cell-membrane, and is rendered useful to the rest of the plant, into whose cells, not quite walled up by carbonate of lime, it enters like sap, and circulates. The carbonate of lime can only get in by there being some minute quantity in the sea-water, and there is sufficient in the chalky spots and limestone shores, not only dissolved by the sea-water, but held in suspension by it. The water is ever on the move, passing over the coralline, and in a few weeks a few grains, for they make a great show, are ab-

sorbed and deposited in it. Small sea-snails browse on the corallines, and have to thank them for their lime, which is necessary for their shell.

There are some other plants found at low-tide marks which are calcareous, but instead of being jointed, like the corallines, they form irregular and rounded little blocks, or simple papery-looking expansions on some of the larger-leaved sea-weeds. They are usually white and hard, and no one would consider them to be of a vegetable nature were their microscopic anatomy not known. They have a great resemblance in mineral structure to the coralline, and are called *Melobesia* or *Nullipores*.

The sea-weeds are, as may have been gleaned from the last few pages, divisible into red, olive, or dark and green kinds, and one of their most interesting studies relates to the method of reproduction. Many sea-weeds are annual and die in the winter, so they must be reproduced by seed, or something like it; others are of two or more years' growth, and outlive the winter, but in the end they must have some method of perpetuating their kind. Some are perennial, or constantly growing. Certain kinds are only found in the spring and summer, others are always to be met with, and some produce spores, or the matter out of which future weed grows, in summer, and others in the autumn and winter. The geographical range of some of the British sea-weeds is immense, and not a few kinds are found at the Antipodes.

SARGASSUM.—CUTHBERT COLLINGWOOD

AMONG the many remarkable phenomena connected with the Gulf Stream not the least remarkable is the existence of those floating meadows of sea-weed commonly known as the Gulf-weed or Sargassum, whose accumulations, within certain parallels of latitude and longitude, have given to that area the name of the Sargasso Sea. These marine prairies, as they have been called, have attracted the notice of all navigators since the time of Columbus, who, in his first voyage, received his earliest check upon falling in with them. The great pioneer entered the Sargasso Sea in lat. 26° N., and long. 48° W., and his timid shipmates at once took fright at the marvelous appearance, feeling assured that their ships would be entangled in the weed until they were starved to death, or that they were about to strike on some unknown coast. In this part, he says, "the sea was covered with such a quantity of sea-weed, like little branches of the fir-trees which bear the pistachio nuts, that we believed the ships would run aground for want of water." They could not understand how such vast quantities of vegetation could merely float on the surface, and the appearance of a lobster among the weed confirmed their fears; and deeming it necessary that they must be either in, or approaching shoal water, they entreated the heroic discoverer to turn the ship's head. But happily he never wavered, and on the tropic, in long. 66° , the

first vessel which had ever entered the Sargasso Sea emerged again into clear water.

The extent of the Sargasso Sea is in due proportion to the vast natural agency to which it primarily owes its existence. It stretches from 20° to about 65° West longitude, and from between the parallels of 20° and 45° is of considerable width, narrowing from 12° in its widest part to about 4° or 5° where least developed; while the remaining 20° of westerly extent takes the form of a narrow belt of various detached tracts, influenced as to situation by local currents, and averaging 4° or 5° only in width. An idea may be obtained of its area by the comparison of Maury, who states that it is equal to the great valley of the Mississippi; or still better, perhaps, from Humboldt's estimate, that it was about six times as large as the Germany of his day.

But, although the geographical boundaries given above are those usually recognized by hydrographers for the Sargasso Sea, it must not be supposed that they are invariable. It may, however, be correctly stated, that it occupies the great sweep made by the Azores, Canaries, and Cape de Verde Islands in the East; while the elongated westerly belt extends as far as between the Bermudas and West Indian islands.

The earlier navigators often found the Gulf-weed a serious impediment to their progress. Lærius mentions that for fifteen continuous days he passed through one unbroken meadow (Praderias de yerva, or sea-weed prairies, as Oviedo characteristically calls them), so that he could find no way through for

oars. On certain occasions it has been found that the speed of vessels through the Sargasso Sea has been materially retarded; and it has been described as so thick that, to the eye, at a little distance it appears to be substantial enough to walk upon.

That this is not the condition met with under all circumstances is proved by the fact that passing through this region in 1867, the writer made a seven days' voyage through its central portion, during which the sea was at no time covered with the weed, so as to form a continuous meadow. It made its appearance usually in large patches, generally upon the surface, but sometimes apparently sunk to some distance below it. It varied considerably in appearance—was sometimes dark-colored, dense, and compact, and covered with berries; at others, pale and attenuated, with few berries. The masses, on some days were round and shapely, and usually scattered somewhat indiscriminately over the surface of the sea. Occasionally only a few small tufts appeared for many hours; and on one day the only sign of its presence was a long narrow streak, extending across the ocean as far as the eye could reach in the direction of the wind. The fact, indeed, is that the Sargasso Sea, dependent as it is upon a great physical phenomenon, changes its position according to the seasons, storms, and winds: its mean position remaining the same as it has been ascertained by observations during many years past. The Gulf Stream is the great power which maintains these marine pastures—a current whose impulse and origin, according to Humboldt, are to be sought to the south of the

Cape of Good Hope—after a long circuit it pours itself from the Caribbean Sea and the Mexican Gulf through the Straits of the Bahamas, and following a course from south-southwest to north-northeast, continues to recede from the shores of the United States until, further deflected to the eastward by the banks of Newfoundland, it approaches the European coast. At the point where the Gulf Stream is deflected from the banks of Newfoundland toward the east, it sends off branches to the south near the Azores. This is the situation of the Sargasso Sea.

Patches of the weed are always to be seen floating along the outer edge of the Gulf Stream. Now, if bits of cork, or chaff, or any floating substance, says Captain Maury, be put in a basin, and a circular motion be given to the water, all the light substances will be found crowding together near the centre of the pool, where there is the least motion. Just such a basin is the Atlantic Ocean to the Gulf Stream; and the Sargasso Sea is the centre of the whirl.

The Gulf-weed itself has so peculiar a history that it forms not the least remarkable point of interest in the description of the Sargasso Sea. It is one of the numerous species of the genus *Sargassum*, which is among the most natural and readily distinguished genera of the family of *Fucaceæ*. The great cryptogamist, Agardh, enumerates sixty-two species of *Sargassum*, of which the one concerning which we are speaking is the *Sargassum bacciferum*, called *Fucus natans* by Linnæus, and *Fucus sargasso* by Gmelin. The Spanish word *Sargazo*, or *Sargaço*,

meaning sea-weed, supplies its common English name.

The integument is leathery and the general color brown, of varying shades, sometimes light and sometimes dark. The most striking peculiarity, on a cursory view, is the abundance of globular cells, which have been taken by the unlearned for fruit, but which are in reality merely receptacles of air, by means of which the plant not only floats upon the surface of the ocean, but also is enabled to support vast numbers of marine animals, which find shelter among its tangled fronds. Columbus, the first discoverer of the Sargasso Sea, described the meadows as yellow like dry hay-seed, bearing leaves of common rue, with numerous berries, which turn black in drying like juniper berries. These berries have received the name of *rasins de tropique*.

There is one point in the history of the Sargassum which has excited the attention of all observers, and more particularly of botanists. It is the fact that the Sargassum is always found floating upon the deep sea, and is yet destitute of any apparent means of propagation. Agardh remarked that no fruit nor root could be detected; and expressed his belief that it grew in the depths of the ocean and was torn up by the waves. This belief was very general at one time, and it was supposed that the perfect plant was unknown; but that the Gulf Stream collected together the torn-off masses of its vesicular summits. Rumphius suggested that the Sargassum fed upon the fat exhalations and oily effluvia of dead fish, and other organic substances entangled in it. Even

modern publications state that there is reason to think that it is first attached to the bottom of the comparatively shallow parts of the sea; but the Gulf-weed is never found so attached. It always floats; and is healthy and abundant in that condition, never exhibiting any organs of fructification, though constantly putting out new fronds.

It does not appear that any other species of *Sargassum* is originally destitute of roots, even those most closely allied to *Sargassum bacciferum*, though some of them are not infrequently found both in the fixed, and in considerable masses in the floating state, retaining vitality, and probably propagating themselves in the same manner. Professor Hervey conjectured that the Gulf-weed might be a pelagic variety of *Sargassum vulgare*, in the same way as the variety *subcostatus* of *Fucus vesiculosus* has never been found attached, growing in salt marshes. In the Mediterranean vast quantities of *Fucus vesiculosus* occur under a peculiar form, consisting entirely of specimens derived from sea-born weed, carried in by the current which sets in to that sea from the Atlantic.

GLOSSARY OF BOTANICAL TERMS

A

ABBREVIATE (*abbreviare*, to shorten), used to indicate that one part is shorter than another.

ABERRANT, deviating from the natural form.

ABORTION, suppression of an organ, depending on non-development.

ABRADED, rubbed off.

ABRUPT, ending in an abrupt manner, as the truncated leaf of the tulip-tree; *abruptly pinnate*, ending in two pinnæ—in other words, paripinnate; *abruptly acuminate*, a leaf with a broad extremity, from which a point arises.

ACAULESCENT, without an evident stem.

ACCESSORY, an addition to a usual number.

ACCRESCENT, when parts continue to grow and increase after flowering, as the calyx of *Physalis* and the styles of *Anemone pulsatilla*.

ACCRETION, growing of one part to another.

ACCUMBENT, applied to the embryo of *Crucifera* when the cotyledons have their edges applied to the folded radicle.

ACEROSE, needle-like, narrow and slender, with a sharp point.

ACHENE, or **ACHÆNIUM**, a monospermous seed-vessel which does not open, but the pericarp of which is separable from the seed.

ACHLAMYDEOUS, having no floral envelope.

ACHROMATIC, applied to lenses which prevent chromatic aberration, *i. e.*, show objects without any prismatic colors.

ACICULAR, like a needle in form.

ACICULUS, a strong bristle.

ACINACIFORM, shaped like a sabre or cimeter.

ACOTYLEDONOUS, having no cotyledons.

ACROCARPI, mosses having their fructification terminating the axis.

ACROGENOUS, having a stem increasing by its summit.

ACULEATE, furnished with prickles.

ACULEUS, a prickle, a process of the bark, not of the wood, as in the rose.

ACUMINATE, drawn out into a long point.

ACUTE, terminating in a sharp point.

ADHERENT, adhesion of parts that are

normally separate, as when the calyx is united to the ovary.

ADNATE, when an organ is united to another throughout its whole length; as the stipules to the petiole in roses, and the filament and anther in *Ranunculus*.

ADRESSED, or **APPRESSED**, closely applied to a surface.

ADULT, full grown.

ADVENTITIOUS, organs produced in abnormal positions, as roots arising from aerial stems.

ÆRUGINOUS, having the color of verdigris.

ÆSTIVATION, the arrangements of the parts of the flower in the flower-bud.

AGGLOMERATED, collected in a heap or head.

AGGREGATE, gathered together.

ALA, a wing, applied to the lateral petals of papilionaceous flowers, and to membranous appendages of the fruit, as in the elm, or of the seed, as in pines.

ALBUMEN, the nutritious matter stored up with the embryo within the seed, called also Perisperm and Endosperm.

ALBURNUM, the outer young wood of a dicotyledonous stem.

ALEXIPHARMIC, that which counteracts poisons.

ALGOLGY, the study of sea-weeds.

ALTERNATE, arranged at different heights on the same axis, and toward different sides.

ALVEOLÆ, regular cavities on a surface, as in the receptacle of the sunflower, and in that of *Nelumbium*.

ALVEOLATE, like a honeycomb.

AMENTUM, a catkin, or deciduous unisexual spike; plants having catkins are *Amentiferous*.

AMNIOS, the fluid or semi-fluid matter in the embryo-sac.

AMORPEOUS, without definite form.

AMPHISARCA, an indehiscent, multi-locular fruit, with a hard exterior, and pulpy round the seeds, as seen in the Baobab.

AMPHITROPAL, an ovule, curved on itself, with the hilum in the middle.

AMPLEXICAUL, embracing the stem over a large part of its circumference.

AMPULLA, a hollow leaf, as in *Utricularia*.

AMYLACEOUS, starch-like.

ANASTOMOSING, insculation of vessels.

ANASTOMOSIS, union of vessels; union of the final ramifications of the veins of a leaf.

ANATROPAL, an inverted ovule, the hilum and micropyle being near each other, and the chalazal at the opposite end.

ANCEPS, two-edged.

ANDRECIUM, the male organs of the flower.

ANDROGYNOUS, male and female flowers on the same peduncle, as in some species of *Carex*.

ANDROPHORE, a stalk supporting the stamens, often formed by a union of the filaments.

ANFRACTUOSE, wavy or sinuous, as the anthers of *Cucurbitaceæ*.

ANGIOSPERMOUS, having seeds contained in a seed-vessel.

ANISOSTEMONOUS, stamens not equal in number to the floral envelopes, nor a multiple of them.

ANNOTINUS, a year old.

ANNULUS, applied to the elastic rim surrounding the sporangia of some ferns, also to a cellular rim on the stalk of the mushroom, being the remains of the veil.

ANTERIOR, same as inferior when applied to the parts of the flower in their relation to the axis.

ANTHELMINTIC, a vermifuge.

ANTHER, the part of the stamen containing pollen.

ANTHERIDIUM, the male organ in cryptogamic plants, frequently containing moving filaments.

ANTHERIFEROUS, bearing anthers.

ANTHEROZOIDS, moving filaments in an antheridium.

ANTHESIS, the opening of the flower.

ANTHOCARPOUS, applied to fruits, formed by the ovaries of several flowers.

ANTHODIUM, the capitulum or head of flowers of the Composite plants.

ANTHOPHORE, a stalk supporting the inner floral envelopes, and separating them from the calyx.

ANTHOS, a flower; in composition, *Antho*; in Latin, *Flos*.

ANTHOTAXIS, the arrangement of the flowers on the axis.

APETALOUS, without petals; in other words, monochlamydeous.

APHYLLOUS, without leaves.

APICULATE, having an apiculus.

APICULUS, or **APICULUM**, a terminal soft point, springing abruptly.

APOCARPOUS, ovary and fruit composed of numerous distinct carpels.

APOPHYSIS, a swelling at the base of the theca in some mosses.

APOTHECIUM, the rounded, shield-like fructification of lichens.

APTEROUS, without wings or membranous margins.

ARACHNOID, applied to fine hairs so entangled as to resemble a cobweb.

ARBOREOUS, tree-like.

ARCHEGONIUM, the female organ in cryptogamic plants.

ARCULATE, curved in an arched manner.

AREOLÆ, little spaces on a surface.

AREOLATE, divided into distinct angular spaces, or areolæ.

ARILLATE, having an arillus.

ARILLUS and **ARILLODE**, an extra covering on the seed; the former proceeding from the placenta, the latter from the exostome, as in mace.

ARISTA, an awn, a long pointed process.

ARMATURE, the hairs, prickles, etc., covering an organ.

ARTICULATED, jointed, separated easily and cleanly at some point.

ASCENDING, applied to a procumbent stem which rises gradually from its base: to ovules attached a little above the base of the ovary; and to hairs directed toward the upper part of their support.

ASCI, tubes containing the sporidia of the cryptogamia.

ASCIDIUM, a pitcher-like leaf, as in *Nepenthes*.

ASPERITY, roughness, as on the leaves of *Boraginaceæ*.

ATROPAL, the same as orthotropous.

ATTENUATE, thin and slender.

AURICULATE, having appendages; applied to leaves having lobes (ear-shaped) or leaflets at their base.

AWN and **AWNED**. See *Arista*.

AXIL, the upper angle, where the leaf joins the stem.

AXILE, or **AXIAL**, belonging to the axis.

AXIL-FLOWERING, flowering in the axilla.

AXILLARY, arising from the axil of a leaf.

AXIS is applied collectively to the stem and root—the ascending and descending axis, respectively.

B

BACCA, berry, a unilocular fruit, having a soft outer covering and seeds immersed in pulp.

BACCATE, resembling a berry.

BALAUSTA, the fruit of the pomegranate.

BARBATE, bearded, having tufts of hair.

BARK (*cortex*), the outer cellular and fibrous covering of the stem; separate from the wood in dicotyledons.

BAREN, not fruitful; applied to male flowers, and to the non-fructifying fronds of ferns.

BASAL, or **BASILAR**, attached to the base of an organ.

BASIDIUM, a cell bearing on its exterior one or more spores in some fungi, which are hence called *Basidiosporous*.

BAST, or **BASS**, the inner fibrous bark of dicotyledonous trees.

BEAKED, like the sharp-pointed beak of a bird in form.

BEDEGUAR, a hairy excrescence on the branches and leaves of roses, caused by an attack of a cynips.

- BIDENTATE**, having two tooth-like processes.
- BIFARIOS**, in two rows, one on each side of an axis.
- BIFID**, two-cleft, cut down to near the middle into two parts.
- BIFORINE**, a raphidian cell with an opening at each end.
- BILABiate**, having two lips.
- BILOBED**, divided into two lobes.
- BILOCULAR**, having two cells.
- BINATE**, applied to a leaf composed of two leaflets at the extremity of a petiole.
- BIPARTITE**, cut down to near the base into two parts.
- BIPINNATE**, a compound leaf, divided twice in a pinnate manner.
- BIPINNATIFID**, a simple leaf, with lateral divisions extending to near the middle, and which are also similarly divided.
- BIPINNATIPARTITE**, differing from bipinnatifid in the divisions extending to near the midrib.
- BIPPLICATE**, doubly folded in a transverse manner.
- BISERRATE**, when the serratures are themselves serrate.
- BITERNATE**, a compound leaf divided into three, and each division again divided into three.
- BLADE**, the lamina or broad part of a leaf, as distinguished from the petiole or stalk.
- BLANCHING**. See *Etiolation*.
- BLETTING**, a peculiar change in an austere fruit, by which, after being pulled, it becomes soft and edible, as in the medlar.
- BLISTERED**, applied to raised spots in leaves.
- BOLE**, the trunk of a tree.
- BOTHRENCHYMA**, dotted or pitted vessels.
- BRAC**T, a leaf more or less changed in form, from which a flower or flowers proceed; flowers having bracts are called *bracteated*.
- BRAC**TEOLE, a small bract at the base of a separate flower in a multifloral inflorescence.
- BRANCHLETS**, little branches.
- BRYOLOGY**, the study of mosses; same as muscology.
- BULB**, an underground stem covered with scales.
- BULBIL**, or **BULBLET**, separate buds in the axil of leaves, as in some lilies.
- BYSSOID**, very slender, like a cobweb.
- CADUCOUS**, falling off very early, as the calyx of a poppy.
- CÆSIOUS**, gray.
- CÆSPITOSE**, growing in tufts.
- CALCAR**, a spur, projecting hollow or solid process from the base of an organ, as in the flower of Larkspur or Snapdragon; such flowers are called *calcarate*, or spurred.
- CALCEOLATE**, slipper-like, applied to the hollow petals of some orchids; also to the corolla of *Calceolaria*.
- CALLOSITY**, or **CALLOUS**, a leathery or hardened thickening on a limited portion of an organ.
- CALYCFLOREÆ**, a sub-class of polypetalous Exogens, having the stamens attached to the calyx.
- CALYCINE**, belonging to the calyx.
- CALYPTRATE**, in form, resembling an extingisher.
- CALYX**, the outer envelope of a flower.
- CAMBium**, the young active cells between the bark and the young wood.
- CAMPANULATE**, shaped like a bell, as the flower of harebell.
- CAMPYLOTROPAL**, a curved ovule, with the hilum, micropyle, and chalazal near each other.
- CANALICULATE**, channeled, having a longitudinal groove or furrow.
- CANCELLATE**, latticed, composed of veins alone.
- CANESCENT**, hoary.
- CAPILLARY**, filiform, thread-like, or hair-like.
- CAPITATE**, pin-like, having a rounded summit, as some hairs.
- CAPITULUM**, head of flowers in *Compositæ*.
- CAPREOLATE**, having tendrils.
- CAPSULE**, a dry seed-vessel, opening by valves, teeth, pores, or a lid.
- CARINA**, keel, the two partially united lower petals of papilionaceous flowers.
- CARINATE**, keel-shaped.
- CARPEL**, the leaf which contains the ovules. Several carpels may enter into the composition of one pistil.
- CARPOLOGY**, the study of fruits.
- CARPOPHORE**, a stalk bearing the pistil, and raising it above the whorl of the stamens, as in *Lychnis* and *Caparis*.
- CARUNCLE**, a fleshy or thickened appendage of the raphe of the seed.
- CARYOPSIS**, the monospermal seed-vessel of a grass, the pericarp being adherent with the seed.
- CATKIN**, same as Amentum.
- CAUDATE**, having a tail or feathery appendage.
- CAUDE**X, the stem of palms and of tree ferns.
- CAUDICLE**, the process supporting a pollen mass in orchids.
- CAULESCENT**, having an evident stem.
- CAULICLE**, the rudimentary axis of the embryo.
- CAULINE**, produced on the stem.
- CAUSTICITY**, having a burning quality.
- CELLULAR**, composed of cells.
- CELLULOSE**, the chemical substance of which the cell wall is composed.
- CENTIMETRE**, a French measure, equal to 0.3937079 British inch.
- CENTRIFUGAL**, applied to that kind of inflorescence in which the central flower opens first.
- CENTRIPETAL**, applied to that kind of inflorescence in which the flowers at the circumference or base open first.

CERAMIDIUM, an ovate conceptacle, having a terminal opening, and with a tuft of spores arising from the base; seen in *Algae*.

CEREAL, a general term applied to wheat, oats, barley, and rye.

CHALAZA, the place where the nourishing vessels enter the nucleus of the ovule.

CHLOROPHYLL, the green coloring matter of leaves.

CHORISIS, separation of a lamina from one part of an organ, so as to form a scale or a doubling of the organ; it may be either transverse or collateral.

CHROMULE, the coloring matter of the cells of flowers; also of the lower *Algae*.

CILIA (*cilium*), short, stiff hairs fringing the margin of a leaf; also the delicate vibratile hairs of zoospores.

CILIATO-DENTATE, toothed and fringed with hairs.

CIRCINATE, rolled up like a crosier, as the young fronds of ferns.

CIRCUMSCISSILE, cut round in a circular manner, such as seed-vessels opening by a lid.

CIRCUMSCRIPTION, the periphery or margin of a leaf.

CIRRHUS, a modified leaf in the form of a tendril.

CLATHRATE, latticed, like a grating.

CLAVATE, club-shaped, becoming gradually thicker toward the top.

CLAW, the narrow base of some petals, corresponding with the petiole of leaves.

CLEFT, divided to about the middle.

CLOVES, applied to young bulbs, as in the onion.

CLYPEATE, having the shape of a buckler.

COCCIDIUM, a rounded conceptacle in *Algae* without pores, and containing a tuft of spores.

COCHLEAR, a kind of aestivation, in which a helmet-shaped part covers all the others in the bud.

COCHLEARIFORM, shaped like a spoon.

COCHLEATE, shaped like a snail shell.

COLEORHIZA, a sheath, surrounding the radicles of a monocotyledonous embryo.

COLLATERAL, placed side by side, as in the case of some ovules.

COLLUM, neck, the part where the plumule and radicle of the embryo unite.

COLUMELLA, central column in the sporangia of mosses.

COLUMN, a part of a flower of an orchid supporting the anthers and stigma, and formed by the union of the styles and filaments.

COMA, a tuft of hair on a seed.

COMMISSURE, union of the faces of the two achenes in the fruit of *Umbelliferae*.

COMOSE, furnished with hairs, as the seeds of the willow.

COMPOUND, composed of several parts, as a leaf formed by several leaflets.

COMPRESSED, flattened laterally or lengthwise.

CONCENTRIC, curves with common centre.

CONCEPTACLE, a hollow sac containing a tuft or cluster of spores.

CONCRETE, hardened into a mass.

CONDUCTING TISSUE, applied to the loose cellular tissue in the interior of the style.

CONDUPLICATE, followed upon itself, applied to leaves and cotyledons.

CONE, a dry multiple fruit, formed by bracts covering naked seeds.

CONFERRUMINATE, indistinguishably united together.

CONFEROID, formed of a single row of cells, or having articulations like a *Conferva*.

CONFLUENT, when parts unite together in the progress of growth.

CONJUGATION, union of two cells, so as to develop a spore.

CONNATE, when parts are united, even in the early state of development; applied to two leaves united by their bases.

CONNECTIVE, the part which connects the anther-lobes.

CONNIVENT, when two organs, as petals, arch over so as to meet above.

CONSTRICTED, contracted in some particular place.

CONTORTED, when the parts in a bud are imbricated and regularly twisted in one direction.

CONVOLUTE, when a leaf in the bud is rolled upon itself.

CORDATE, of leaves heart-shaped at the base.

CORDIFORM, having the shape of a heart.

CORIACEOUS, having a leathery consistence.

CORM, thickened underground stem, as in *Arum* and *Colchicum*.

CORNUTE, horned.

COROLLA, the inner envelope of the flower.

COROLLIFLORÆ, gamopetalous exogens.

CORONA, a coralline appendage, as the crown of the daffodil.

CORPUSCLE, a small body or particle.

CORRUGATED, wrinkled or shriveled.

CORTEX, the bark.

CORTICAL, belonging to the bark.

CORYMB, a raceme, in which the lower stalks are the longest, and all the flowers come very nearly to a level above.

COSTATE, provided with ribs; primary.

COTYLEDON, the temporary leaf of the embryo.

CREMOCARP, the fruit of *Umbelliferae*, composed of two separable achenes or mericarps.

CRENATE, having superficial, rounded, marginal notches.

CRENATURES, divisions of the margin of a crenate leaf.

CREST, an appendage to fruits or seeds.

CRIBRIFORM, riddled with holes.

CRISP, having an undulated margin.

CRUCIFORM, arranged like the parts of a cross, as the flowers of *Cruciferae*.
 CRUSTACEOUS, hard, thin, and brittle.
 CRYPTOGAMOUS, with the organs of reproduction obscure.
 CUCULATE, formed like a hood or cowl.
 CULM, stem or stalk of grasses.
 CUNEIFORM, or CUNEATE, shaped like a wedge.
 CUPULA, the cup of the acorn, formed by aggregate bracts.
 CUSPIDATE, prolonged into an attenuated point.
 CUTICLE, the thin membrane that covers the epidermis.
 CYCLOSIS, movement of the latex in laticiferous vessels, and of the fluid-cell contents within the cell.
 CYMBIFORM, shaped like a boat.
 CYME, a kind of definite inflorescence, in which the flowers are in racemes, corymbs, or umbels, the successive central flowers expanding first.
 CYPSELA, monospermal fruit of *Compositae*.
 CYTOBLAST, the nucleus of a cell.
 CYTOGENESIS, cell development.

D

DECIDUOUS, falling off after performing its functions for a limited time, as the calyx of *Ranunculus*.
 DECIDUOUS TREES, those which lose their leaves annually.
 DECIMETRE, the tenth part of a metre, or ten centimetres.
 DECLINATE, directed downward from its base.
 DECOMPOUND, a leaf cut into numerous compound divisions.
 DECORTICATED, deprived of bark.
 DECUMBENT, lying flat along the ground, and rising from it at the apex.
 DECURRENT, leaves which are attached along the side of a stem below their point of insertion; such stems are often called winged.
 DECUSSATE, opposite leaves crossing each other in pairs at right angles.
 DEDUPLICATION, same as Chorisis.
 DEFINITE, applied to inflorescence when it ends in a single flower, and the expansion of the flower is centrifugal; also when the number of the parts of an organ is limited, as when the stamens are under twenty.
 DEFLEXED, bent downward in a continuous curve.
 DEFOLIATION, the fall of the leaves.
 DEGENERATION, when an organ is changed from its usual appearance, and becomes less highly developed as when scales take the place of leaves.
 DEHISCENCE, mode of opening of an organ, as of the seed-vessels and anthers.
 DELTOID, like the Greek Δ in form.
 DEMULCENT, an emollient.

DENTATE, toothed, having short triangular divisions of the margin.
 DENTICULATE, finely toothed, having small tooth-like projections along the margin.
 DENTIFORM, tooth-shaped.
 DEPENDENT, hanging down.
 DEPRESSED, flattening of a solid organ from above downward.
 DETERGENT, having a cleansing power.
 DIADELPHOUS, stamens in two bundles, united by their filaments.
 DIANDROUS, having two stamens.
 DIAPHANOUS, transparent.
 DICHLAMYDEOUS, having calyx and corolla.
 DICHOTOMOUS, stem dividing by twos.
 DICLINOUS, unisexual flower either monœcious or diœcious.
 DICOTYLEDONOUS, embryo having two cotyledons.
 DICTYOGENOUS, applied to monocotyledons having netted veins.
 DIDYNAMOUS, two long and two short stamens.
 DIFFUSE, scattered.
 DIGITATE, compound leaf, composed of several leaflets attached to one point.
 DIGYNOUS, having two styles.
 DIMEROUS, when the parts of a flower are in twos.
 DIMIDIATE, when one-half of an organ is smaller than the other half.
 DIOECIOUS, stamiferous and pistilliferous flowers on separate plants.
 DIPLOSTEMONOUS, stamens double the number of the petals or sepals.
 DIPTEROUS, having two wings.
 DISCOID, in the form of a disk or flattened sphere; *discoid pith*, divided into cavities by disks.
 DISK, a part intervening between the stamens and the pistils in the form of scales, a ring, etc.
 DISKS, the peculiar rounded and dotted markings on the fibres of coniferous wood.
 DISSECTED, cut into a number of narrow divisions.
 DISSEPIMENT, a division in the ovary; true when formed by the edges of the carpels, false when formed otherwise.
 DISTICHIOUS, in two rows on opposite sides of a stem.
 DIVARICATING, branches coming off from the stem at a very wide or obtuse angle.
 DODECANDROUS, having twelve stamens.
 DOLABRIFORM, shaped like an axe.
 DORSAL, applied to the suture of the carpel which is furthest from the axis.
 DOUBLE FLOWER, when the organs of reproduction are converted into petals.
 DRUPE, a fleshy fruit like the cherry, having a stony endocarp.
 DRUPELS, small drupes aggregated to form a fruit, as in the raspberry.
 DURAMEN, heart-wood of dicotyledonous trees.

E

ELATERS, spiral fibres in the spore-cases of *Hepatica*.
 ELLIPTICAL, having the form of an ellipse.
 EMARGINATE, with a notch at the end.
 EMBRACING. This is said to be the case when a leaf clasps the stem.
 EMBRYO, the young plant contained in the seed.
 EMBRYO-SAC, the cell in which the embryo is formed.
 ENDOCARP, the inner layer of the pericarp, next the seed.
 ENDOCHROME, the coloring matter within the cells of the lower plants.
 ENDOGEN, a monocotyledon.
 ENDOPHLEUM, the fibrous inner bark or liber.
 ENDOPLEURA, the inner covering of the seed.
 ENDORHIZAL, numerous rootlets arising from *within* a common radicle, and passing through sheaths, as in endogenous germination.
 ENDOSMOSE, movement of fluids inward through a membrane.
 ENDOSPERM, albumen formed within the embryo-sac.
 ENDOSTOME, the inner foramen of the ovule.
 ENDOTHECIUM, the inner coat of the anther.
 ENSIFORM, in the form of a sword, as the leaves of *Iris*.
 ENTIRE (*integer*), without marginal divisions.
 ENVELOPES, FLORAL, the calyx and corolla.
 EPICALYX, outer calyx formed either of sepals or bracts, as in mallow and *Potentilla*.
 EPICARP, the outer covering of the fruit.
 EPICHLIUM, the terminal portion of the lip (*labellum*) in orchids.
 EPIDERMIS, the cellular layer covering the external surface of plants.
 EPIGYNOUS, above the ovary by adhesion to it.
 EPIPETALOUS, inserted on the petals.
 EPIPHYLLOUS, growing upon a leaf.
 EPIPHYTES, attached to another plant, and growing suspended in the air.
 EPISPERM, the external covering of the seed.
 EQUIVANT, applied to leaves folded longitudinally, and overlapping each other without any involution.
 ERECT, applied to an ovule which rises from the base of the ovary.
 ERODED, gnawed or bitten.
 EROSE, irregularly toothed, as if gnawed.
 ERUMPENT, as if bursting through the epidermis.
 ESCHAROTIC, having the power to scar or burn the skin.
 ETHERIO, the aggregate drupes forming the fruit of *Rubus*.
 ETIOLATION, blanching; losing color through growth in the dark.

EXALBUMINOUS, without a separate store of albumen or perisperm.
 EXANNULATE, without a ring; applied to some ferns.
 EXCENTRIC, removed from the centre or axis; applied to a lateral embryo.
 EXCIPULUS, a receptacle containing fructification in lichens.
 EXCORIATED, stripped of skin or bark.
 EXCURRENT, running out beyond the edge or point.
 EXOGEN, dicotyledon.
 EXORHIZAL, radicle proceeding directly from the axis, and afterward branching, as in exogens.
 EXOSMOSE, the passing outward of a fluid through a membrane.
 EXOSTOME, the outer opening of the foramen of the ovule.
 EXOTHECIUM, the outer coat of the anther.
 EXsertED, extended beyond an organ, as stamens beyond the corolla.
 EXSICCATED, dried up.
 EXSTIPULATE, without stipules.
 EXTINE, the outer covering of the pollen grain.
 EXTRA-AXILLARY, removed from the axil of the leaf, as in the case of some buds.
 EXTRORSE, applied to anthers which dehisce on the side furthest removed from the pistil.

F

FÆCULA, starchy matter.
 FALCATE, or FALCIFORM, bent like a sickle.
 FARINACEOUS, mealy, containing much starch.
 FASCATION, union of branches of stems so as to present a flattened ribbon-like form.
 FASCICLE, a shortened umbellate cyme, as in some species of *Dianthus*.
 FASCICULATE, arranged in bundles.
 FASTIDIATE, having a pyramidal form, from the branches being parallel and erect, as in Lombardy poplar.
 FAUCES, the gaping part of a monopetalous corolla.
 FEATHER-VEINED, a leaf having the veins passing from the midrib at a more or less acute angle, and extending to the margin.
 FECUNDATION, fertilization.
 FENESTRATE, applied to a leaf with perforations.
 FERRUGINOUS, rusty.
 FERTILE, applied to pistillate flowers, and to the fruit-bearing fronds of ferns.
 FIBROUS, composed of numerous fibres, as some roots.
 FIBRO-VASCULAR TISSUE, containing vessels and fibres.
 FILAMENT, stalk supporting the anther.
 FILAMENTOUS, a string of cells placed end to end.
 FILIFORM, like a thread.
 FIMBRIATED, fringed at the margin.

FISSIPAROUS, dividing spontaneously into two parts by means of a septum.

FISSURE, a straight slit in an organ for the discharge of its contents.

FISTULOUS, hollow, like stems of grasses.

FLABELLIFORM, fan-shaped, as the leaves of some palms.

FLACCID, feeble, weak.

FLAGELLUM, a runner, a weak creeping stem, bearing rooting buds at different points, as in the strawberry.

FLEXUOSE having alternate curvatures in opposite directions.

FLOCCOSE, covered with wool-like tufts.

FLORETS, little florets forming a compound flower.

FOLIACEOUS, having the form of leaves.

POLLICLE, a fruit formed by a single carpel dehiscing by one suture, which is usually the ventral.

FOVEOLATE, having pits or depressions, called foveæ or foveolæ.

FOVILLA, minute granular matter in the pollen grain.

FROND, the leaf-like organ of ferns, bearing the fructification.

FRONDLOSE, applied to cryptogams with foliaceous or leaf-like expansions.

FRUCTIFICATION, the seed or fruit of plants.

FRUSTULES, the parts or fragments into which diatomaceæ separate.

FRUTICOSE, shrubby.

FUGACIOUS, evanescent, falling off early, as the petals of *Cistus*.

FULVOUS, tawny, yellow.

FUNGIOUS, having the substance of fungi or mushrooms.

FUNICULUS, the cord connecting the hilum of the ovule to the placenta.

FURCATE, divided into two branches, like a two-pronged fork.

FURFURACEOUS, scaly or scurfy.

FUSCOUS, blackish brown.

FUSIFORM, shaped like a spindle.

G

GALBULUS, the polygynœcial fruit of juniper.

GAMOPETALOUS, same as monopetalous, petals united.

GAMOPHYLLOUS and **GAMOSEPALOUS**, same as monophyllous and monosepalous, sepals united.

GEMINATE, twin organs combined in pairs; same as binate.

GEMMATION, the development of leaf-buds.

GEMMULE, same as plumule, the first bud of the embryo.

GENICULATE, bent like a knee.

GERMEN, or **GERM**, a name for the ovary.

GERMINAL VESICLE, a germ contained in the embryo-sac, from which the embryo is developed.

GERMINATION, the sprouting of the young plant.

GIBBOSITY, a swelling at the base of an organ, such as the calyx or corolla.

GIBBOUS, swollen at the base, or having a distinct swelling at some part of the surface.

GLABROUS, smooth, without hairs.

GLAND, an organ of secretion consisting of cells, and generally occurring on the epidermis of plants.

GLANDULAR HAIRS, hairs tipped with a gland, as in *Drosera* and Chinese primrose.

GLANS, nut, applied to the acorn and hazel-nut, which are inclosed in an involucre formed of consolidated bracts.

GLAUCCOUS, covered with a pale green bloom.

GLOBOSE, round-shaped.

GLOBULE, male organ of Chara.

GLOCHIDIATE, barbed; applied to hairs with two reflexed points at their summits.

GLOMERULE, a rounded cymose inflorescence, as in *Urtica*.

GLUMACEOUS, chaffy.

GLUME, a bract covering the organs of reproduction in the spikelets of grasses.

GLUTEN, a highly nitrogenous substance found in seeds.

GONIDIA, green cells in the thallus of lichens.

GRAIN, caryopsis, the fruit of grasses.

GRUMOUS, collected into granular masses.

GYMNOGEN, a plant with naked seeds, i. e., seed not in a true ovary.

GYMNOSPERMOUS, plants with naked seeds, i. e., seeds not in a true ovary; such as conifers.

GYNANDROUS, stamen and pistil united in a common column, as in the *Orchidaceæ*.

GYNOBASE, a central axis, to the base of which the carpels are attached.

GYNÆCIUM, the female organs of the flower.

GYNOPHORE, a stalk supporting the ovary.

GYRATE, same as circinate.

H

HABIT, general external appearance.

HASTATE, halbert-shaped, applied to a leaf with two portions at the base projecting more or less completely at right angles to the blade.

HAULM, dead stems of herbs, as of the potato.

HAUSTORIUM, the sucker at the extremity of the parasitic root of dodder.

HEART-WOOD, same as Duramen.

HELICOIDAL, having a coiled appearance like the shell of a snail; applied to inflorescence.

HERB, a plant with an annual stem, opposed to a woody plant.

HERBACEOUS, green succulent plants which die down to the ground in

winter; annual shoots, with green-colored cellular parts.
HERMAPHRODITE, stamens and pistils in the same flower.
HESPERIDIUM, the fruit of the orange and other *Aurantiaceæ*.
HETEROCYSTS, peculiar large cells in *Nostochineæ*.
HETEROGAMOUS, composite plants having hermaphrodite and unisexual flowers on the same head.
HETEROPHYLLOUS, presenting two different forms of leaves.
HILUM, the base of the seed to which the placenta is attached either directly or by means of a cord. The term is also applied to the mark at one end of some grains of starch.
HIRSUTE, covered with long stiff hairs.
HISPID, covered with long, very stiff hairs.
HISTOLOGY, the study of microscopic tissues.
HOMOGENEOUS, having a uniform structure or substance.
HYALINE, transparent or colorless.
HYBRID, a plant resulting from the fecundation of one species by another.
HYMENIUM, the part which bears the spores in Agarics.
HYPANTHODIUM, the receptacle of *Dorstenia*, bearing many flowers.
HYPOCHILUM, the lower part of the labellum of orchids.
HYPOCRATERIFORM, shaped like a salver, as the corolla of *Primula*.
HYPOGEOUS, under the surface of the soil; applied to cotyledons.
HYPOGYNOUS, inserted below the ovary or pistil.

I

IMBRICATE, parts overlying each other like tiles on a house. *Imbricated aestivation*, the parts of the flower-bud alternately overlapping each other, and arranged in a spiral manner.
IMPARI-PINNATE, unequally pinnate; pinnate leaf ending in an odd leaflet.
INARCHING, a mode of grafting by bending two growing plants toward each other, and causing a branch of the one to unite to the other.
INARTICULATE, without joints or interruption to continuity.
INCISED, cut down deeply.
INCLUDED, applied to the stamens when inclosed within the corolla, and not pushed out beyond its tube.
INCUMBENT, cotyledons with the radicle on their back.
INCURVED, bending inward.
INDEFINITE, applied to inflorescence with centripetal expansion; also to stamens above twenty, and to ovules and seeds when very numerous.
INDEHISCENT, not opening, having no regular line of suture.
INDIGENOUS, an aboriginal native in a country.

INDUPPLICATE, edges of the sepals or petals turned slightly inward in aestivation.
INDUSIUM, epidermal covering of the fructification in some ferns.
INFERIOR, applied to the ovary where it seems to be situated below the calyx, and to the part of the flower furthest from the axis.
INFLEXED, bending inward.
INFLORESCENCE, the mode in which the flowers are arranged on the axis.
INFUNDIBULIFORM, in shape like a funnel, as seen in some gamopetalous corollas.
INNATE, applied to anthers when attached to the top of the filament.
INSPISSATED, thickened or dried-up juice or sap.
INTERNODE, the portion of the stem between two nodes or leaf-buds.
INTERPETIOLAR, between the petioles.
INTERRUPTEDLY-PINNATE, a pinnate leaf in which pairs of small pinnæ occur between the larger pairs.
INTINE, the inner covering of the pollen grains.
INTRAMARGINAL, within the margin.
INTRORSE, applied to anthers which open on the side next the pistil.
INVERSE, inverted.
INVOLUCEL, bracts surrounding the partial umbel of *Umbellifereæ*.
INVOLUCRE, bracts surrounding the general umbel in *Umbelliferae*, the heads of flowers in *Compositæ*, and in general any verticillate bracts surrounding numerous flowers.
INVOLUTE, edges of leaves rolled inward spirally on each side in aestivation.
IRREGULAR, a flower in which the parts of any of the verticils differ in size.
ISOMEROUS, when the whorls of a flower are composed each of an equal number of parts.
ISOSTEMONOUS, when stamens and floral envelopes have the same number of parts or multiples.
ISOTHERMAL, lines passing through places which have the same mean annual temperature.

J

JUGATE, applied to the pairs of leaflets in compound leaves; *Unijugate*, having one pair; *Bijugate*, two pairs, and so on.

K

KEEL, same as Carina.
KNOTTED, when a cylindrical stem is swollen at intervals into a knob.

L

LABELLUM, lip, one of the divisions of the inner whorl of the flower in orchids. This part is in reality su-

perior, but becomes inferior by the twisting of the ovary.

LABIATE, lipped; applied to irregular gamopetalous flowers, with an upper and under portion separated more or less by a hiatus or gap.

LACINIATE, irregularly cut into narrow segments.

LACTESCENT, yielding milky juice.

LACUNA, a large space in the midst of a group of cells.

LAMELLÆ, gills of an Agaric; also applied to flat divisions of the stigma.

LAMINA, the blade of the leaf; the broad part of the petal or sepal.

LANCEOLATE, tapering to each end, but broadest *below* the middle.

LATERAL, arising from the side of the axis, not terminal.

LATEX, granular fluid contained in laticiferous vessels.

LATICIFEROUS, vessels containing latex which anastomose.

LAX, not compact.

LEAFLETS, the small portions of compound leaves.

LEGUME, a pod composed of one carpel, opening usually by a ventral and dorsal suture, as in the pea.

LEGUMINOUS, plants bearing pods.

LENTICEL, a small cellular process on the bark of the willow and other plants.

LENTICULAR, in the form of a doubly-convex lens.

LEPIDOTE, covered with scales or scurf.

LIANES, twining woody plants.

LIBER the fibrous inner bark of endophloeum.

LIP, the calyx which falls from the flower in one piece.

LIGNINE, woody matter which thickens the cell walls.

LIGULATE, strap-shaped.

LIGULE, a process arising from the petiole of grasses, where it joins the blade.

LIGULIFLORÆ, composite plants having ligulate florets.

LIMB, the blade of the leaf; the broad part of a petal or sepal. When sepals or petals are united, the combined broad parts are denominated collectively the limb.

LINE, the twelfth part of an inch.

LINEAR, very narrow when the length greatly exceeds the breadth.

LINGUIFORM, strap-shaped.

LIPPED, having a distinct lip or labellum.

LOBE, large division of a leaf or any other organ, applied often to the divisions of the anther.

LOCULAMENTS, divisions of the cells of a seed-vessel.

LOCULICIDAL, fruit dehiscing through the back of the carpels.

LOCULUS, a cavity in an ovary. The terms are also applied to the anther.

LOCUSTA, a spikelet of grasses.

LODICULE, a scale at the base of the ovary of grapes.

LOMENTUM, an indehiscent legume or

pod with transverse partitions, each division containing one seed.

LURID, a color combining yellow, purple, and gray.

LYRATE, a pinnatifid leaf with a large terminal lobe, and smaller ones as we approach the petiole.

M

MACROPODOUS, applied to the thickened radicle of a monocotyledonous embryo.

MARCESCENT, withering, but not falling off until the part bearing it is perfected.

MEDULLA, the pith.

MEDULLARY RAYS, cellular prolongation uniting the pith and the bark.

MEDULLARY SHEATH, sheath containing spiral vessels, surrounding the pith in exogens.

MEMBRANEUS, having the consistence, aspect, and structure of a membrane.

MERICARP, carpel forming one-half of the fruit of *Umbellifera*.

MÉRITHAL, a term used in place of internode; applied by Gaudichaud to the different parts of the leaf.

MESOCARP, middle covering of the fruit.

MESOCHILUM, middle portion of the labellum of orchids.

MESOPHLEUM, middle layer of bark.

METRE, equal to 39.3707 inches British.

MICROMETER, instrument for measuring microscopic objects.

MICROPYLE, the opening or foramen of the seed.

MILLIMETRE, equal to 0.0393707 English inch.

MONADELPHOUS, stamens united into one bundle by union of their filaments.

MONILIFORM, beaded; cells united with interruptions, so as to resemble a string of beads.

MONOCARPIC, producing flowers and fruit once during life, and then dying.

MENOCHLAMYDEOUS, flowers having a single envelope.

MONOCLINOUS, stamens and pistils in the same flower.

MONOCOTYLEDONOUS, having one cotyledon in the embryo.

MONŒCIOUS, stamens and pistils in different flowers on the same plant.

MONOPETALOUS, same as gamopetalous.

MONOPHYLLOUS, same as gamophyllous.

MONOSEPALOUS, having one sepal or division in the calyx. Same as gamosepalous.

MONSTROSITY, an abnormal development; applied more especially to double flowers.

MORPHOLOGY, the study of the forms which the different organs assume, and the laws that regulate their metamorphoses.

MUCILAGE, a thick viscid fluid.

MUCRO, a stiff point abruptly terminating an organ.

MUCRONATE, having a mucro.
 MUCRONULATE, having a little hard point.
 MURICATE, covered with firm sharp points or excrescences.
 MURIFORM, like bricks in a wall; applied to cells.
 MYCELIUM, the cellular spawn of fungi.

N

NAKED, applied to seeds not contained in a true ovary; also to flowers without any floral envelopes.
 NAPIFORM, shaped like a turnip.
 NATURALIZED, originally introduced by artificial means, but become apparently wild.
 NAVICULAR, hollowed like a boat.
 NECTARY, any abnormal part of a flower. It ought to be restricted to organs secreting a honey-like matter, as in the Crown Imperial.
 NERVATION, same as Nervation.
 NERVES, the veins of leaves.
 NETTED, applied to reticulated nevation.
 NODDING, drooping.
 NODE, the part of a stem from which the leaf-bud proceeds.
 NODOSE, having swollen nodes or articulations.
 NUCLEUS, the body which gives origin to new cells; also applied to the central cellular portion of the ovule and seed.
 NUCULÆ, female part of fructification in the *Characeæ*.
 NUT, any dry one-celled indehiscent fruit with hard pericarp.

O

OBCORDATE, inversely heart-shaped, with the divisions of the heart at the opposite end from the stalk.
 OBLONG, about three-fourths as long as broad.
 OBOVATE, reversely ovate, the broad part of the egg being uppermost.
 OBSOLETE, imperfectly developed or abortive; applied to the calyx when it is in the form of a rim.
 OBTUSE, not pointed, with a rounded or blunt termination.
 OCHRACEOUS, clay or ochre color.
 OCHREA, the sheathing stipule of *Polygonacea*.
 OFFICINAL, sold in the shops.
 OLERACEOUS, used as an esculent pot-herb.
 OLIVACEOUS, having the color of olives.
 OOPHORIDIUM, organ in Lycopodiaceæ containing large spores.
 OPAQUE, dull, not shining.
 OPERCULAR, covered with a lid.
 OPERCULUM, lid; applied to the separable part of the theca of mosses; also applied to the lid of certain seed-vessels.
 OPPOSITE, applied to leaves placed on

opposite sides of the same stem at the same level.
 ORBICULAR, rounded leaf with petiole attached to the centre of it.
 ORGANOGRAPHY, the description of the organs of plants.
 ORTHOTROPAL, ovule with foramen opposite to the hilum; embryo with radicle next the hilum.
 OSMOSE, the force with which fluids pass through membranes in experiments on exosmose and endosmose.
 OVAL, elliptical, blunt at each end.
 OVARY, the part of the pistil which contains the ovules.
 OVATE, shaped like an egg; applied to the broader end of the egg next the petiole or axis.
 OVOID, egg-shaped.
 OVULE, the young seed contained in the ovary.

P

PALE, the part of the flower of grasses within the glume; also applied to the small scaly laminae which occur in the receptacle of some *Compositæ*.
 PALÆOPHYTOLOGY, the study of fossil plants.
 PALEACEOUS, chaffy, covered with small, erect, membranaceous scales.
 PALMATE and PALMATIFID, applied to a leaf with radiating venation, divided into lobes to about the middle.
 PALMATIFARTITE, applied to a leaf with radiating venation, cut nearly to the base in a palmate manner.
 PANDURIFORM, shaped like a fiddle.
 PANICLE, inflorescence of grasses, consisting of spikelets on long peduncles coming off in a racemose manner.
 PANICULATE, forming a panicle.
 PAPILIONACEOUS, corolla composed of vexillum, two alæ, and carina, as in the pea.
 PAPILLOSE, covered with small nipple-like prominences.
 PAPPUS, the hairs at the summit of the ovary in *Compositæ*. They consist of the altered calycine limb. *Pappose*, provided with pappus.
 PARAPHYSES, filaments, sometimes articulated, occurring in the fructification of mosses and other cryptogams.
 PARASITE, attached to another plant, and deriving nourishment from it.
 PARENCHYMA, cellular tissue.
 PARIETAL, applied to placentas on the wall of the ovary.
 PARI-PINNATE, a compound of pinnate leaf ending in two leaflets.
 PARTHENOGENESIS, production of perfect seed with embryo, without the application of pollen.
 PATENT, spreading widely.
 PATULUS, spreading less than when patent.
 PECTINATE, divided laterally into narrow segments like the teeth of a comb.

- PEDATE** and **PEDATIFID**, a palmate leaf of three lobes, the lateral lobes bearing other equally large lobes on the edges next the middle lobe.
- PEDICEL**, the stalk supporting a single flower.
- PEDUNCLE**, the general flower-stalk or floral axis; sometimes it bears one flower, at other times it bears several sessile or pedicellate flowers.
- PELAGIC**, growing in the ocean.
- PELLUCID**, transparent.
- PELORIA**, a name given to a teratological phenomenon, which consists in a flower that is usually irregular becoming regular; for instance, when *Linaria*, in place of one spur, produces five.
- PELTATE**, shield-like, fixed to the stalk by a point within the margin; peltate hairs, attached to their middle.
- PENDULOUS**, applied to ovules which are hung from the upper part of the ovary.
- PENICILLATE**, resembling a camel's-hair pencil.
- PENNI-NERVED**, and **PENNI-VEINED**, the veins disposed like a feather, running from the middle of the leaf to the margin.
- PENTAMEROUS**, composed of different whorls in five, or multiples of that number.
- PEPO**, the fruit of the melon, cucumber, and other *Cucurbitaceæ*.
- PERENNIAL**, living, or rather flowering, for several years.
- PERFOLIATE**, a leaf with the lobes at the base, united on the side of the stem opposite the blade, so that the stalk appears to pass through the leaf.
- PERIANTH**, a general name for the floral envelopes; applied in cases where there is only a calyx, or where the calyx and corolla are alike.
- PERICARP**, the covering of the fruit.
- PERICHÆTAL**, applied to the leaves surrounding the fruit-stalk or seta of mosses.
- PERICLADIUM**, the large sheathing petiole of *Umbellifera*.
- PERIDERM**, a name applied to the outer layer of the barks.
- PERIDIUM**, the envelope of the fructification in gasteromycetous fungi.
- PERIGONE**, same as Perianth. Some restrict the term to cases in which the flower is female, or pistilliferous. It has also been applied to the involucre of *Jungermannia*.
- PERIGYNOUS**, applied to the corolla and stamens when attached to the calyx.
- PERIGYNUM**, applied to the pistil in the genus *Carex*.
- PERIPHERICAL**, applied to an embryo curved so as to surround the albumen, following the inner part of the covering of the seed.
- PERISPERM**, the albumen or nourishing matter stored up with the embryo in the seed.
- PERISTOME**, the opening of the sporangium of mosses after the removal of the calyptra and operculum.
- PERITHECIUM**, a conceptacle in cryptogams, containing spores, and having an opening at one end.
- PERSISTENT**, not falling off, remaining attached to the axis until the part which bears it is matured.
- PERSONATE**, a gamopetalous irregular corolla, having the lower lip pushed upward, so as to close the hiatus between the two lips.
- PERTUSE**, having slits or holes.
- PERULÆ**, the scales of the leaf-bud.
- PETALOID**, like a petal.
- PETALS**, the leaves forming the coralline whorl.
- PETIOULATE**, having a stalk or petiole.
- PETIOLE**, a leaf-stalk; *Petiolule*, the stalk of a leaflet in a compound leaf.
- PHÆNOGAMOUS**, same as Phanerogamous.
- PHANEROGAMOUS**, having conspicuous flowers.
- PHYCOLOGY**, the study of *Algæ*, or seaweeds.
- PHYLLARIES**, the leaflets forming the involucre of composite flowers.
- PHYLLodium**, the leaf-stalk, enlarged so as to have the appearance of a leaf.
- PHYLLOTAXIS**, the arrangement of the leaves on the axis.
- PHYSIOGNOMY**, general appearance, without reference to botanical characters.
- PHYSIOLOGY**, vegetable, the study of the functions of plants.
- PHYTOLOGY**, the study of plants; same as botany.
- PHYTOZOA**, moving filaments in the antheridia of cryptogams.
- PILEATE**, having a cup or lid like the cup of a mushroom.
- PILEORHIZA**, a covering of the root, as in *Lemna*.
- PILEUS**, the cap-like portion of the mushroom, bearing the hymenium on its under side.
- PILOSE**, provided with hairs; applied to pappus composed of simple hairs.
- PINNA**, the leaflet of a pinnate leaf.
- PINNATE**, a compound leaf having leaflets arranged on each side of a central rib.
- PINNATIFID**, a simple leaf cut into lateral segments to about the middle.
- PINNATIPARTITE**, a simple leaf cut into lateral segments, the divisions extending nearly to the central rib.
- PINNULE**, the small pinnae of a bipinnate or tripinnate leaf.
- PISTIL**, the female organ of the flower, composed of one or more carpels; each carpel being composed of ovary, style, and stigma.
- PISTILLATE** and **PISTILLIFEROUS**, applied to a female flower or a female plant.
- PISTILLIDIUM**, the female organ in cryptogams.
- PITCHERS**, vessels of this form at the end of the leaves of *Nepenthes*, etc.
- PITH**, same as Medulla.

PLACENTA, the cellular part of the carpel, bearing the ovule.

PLACENTATION, the formation and arrangement of the placentas.

PLEURENCHYMA, woody tissue.

PLEUROCARPI, mosses with the fructification proceeding laterally from the axils of the leaves.

PLICATE, folded like a fan.

PLUMOSE, feathery; applied to hairs having two longitudinal rows of minute cellular processes.

PLUMULE, the first bud of the embryo, usually inclosed by the cotyledons.

PLURILOCULAR, having many loculements.

PODETUM, a stalk bearing the fructification in some lichens.

PODOSPERM, the cord attaching the seed to the placenta.

POLLARD-TREES, cut down so as to leave only the lower part of the trunk, which gives off numerous buds and branches.

POLLEN, the powdery matter contained in the anther.

POLLEN-TUBE, the tube emitted by the pollen grain after it is applied to the stigma.

POLLINIA, masses of pollen found in orchids and asclepiads.

POLYADELPHOUS, stamens united by their filaments so as to form more than two bundles.

POLYANDROUS, stamens above twenty.

POLYCARPIC, plants which flower and fruit many times in the course of their life.

POLYCOTYLEDONOUS, an embryo having many cotyledons, as in firs.

POLYGAMOUS, plants bearing hermaphrodite as well as male and female flowers.

POLYMORPHOUS, assuming many shapes.

POLYPETALOUS, a corolla composed of separate petals.

POLYPHYLLOUS, a calyx or involucre composed of separate leaflets.

POLYSEPALOUS, a calyx composed of separate sepals.

POME, a fruit like the apple and pear.

POROUS VESSELS, same as pitted or dotted vessels.

POSTERIOR, applied to the part of the flower placed next the axis; same as Superior.

POUCH, the short pod or silicle of some *Crucifera*.

PREMORSE, bitten; applied to a root terminating abruptly, as if bitten off.

PRICKLES, hardened epidermal appendages of a nature similar to hairs.

PRIMINE, the outer coat of the ovule.

PRIMORDIAL UTRICLE, the lining membrane of cells in their early state.

PROCESS, any prominence or projecting part, or small lobe.

PROCUMBENT, lying on the ground.

PROEMBRYO, cellular body in an ovary, from which the embryo and its suspensor are formed. Sometimes Proembryo is used for Prothallus.

PEOLIFEROUS, bearing abnormal buds.

PRONE, prostrate, lying flat on the earth.

PROPAGULUM, an offshoot or germinating bud attached by a thickish stalk to the parent plant.

PROSENCHYMA, fusiform tissue forming wood.

PROTHALLIUM, or **PROTHALLUS**, names given to the first part produced by the spore of an acrogen in germinating.

PROTOPLASM, the nitrogenous gelatinous matter in which the vital activity of cells resides.

PSEUDO-BULB, the peculiar aerial stem of many epiphytic orchids.

PUBESCENCE, short and soft hairs covering a surface.

PULULATING, budding.

PULVERULENT, covered with fine powdery matter.

PULVINATE, shaped like a cushion or pillow.

PULVINOUS, cellular swelling at the point where the leaf-stalk joins the axis.

PUNCTATED, applied to the peculiar dotted woody fibres of *Conifera*.

PUTAMEN, the hard endocarp of some fruits.

PYCNIDES, cysts containing stylospores found in some lichens.

PYXIS, a capsule opening by a lid.

Q

QUATERNARY, composed of parts in fours.

QUINARY, composed of parts in fives.

QUINATE, five leaves coming off from one point.

QUINCUNX, when the leaves in the bud are five, of which two are exterior, two interior, and the fifth covers the interior with one margin, and has its other margin covered by the exterior.

Quincuncial, arranged in a quincunx.

R

RACE, a permanent variety.

RACEME, an indefinite inflorescence, in which there is a primary axis bearing stalked flowers.

RACEMOSE, flowering in racemes.

RACHIS, the axis of inflorescence; also applied to the stalk of the frond in ferns, and to the common stalk bearing the alternate spikelets in some grasses.

RADICAL, belonging to the root; applied to leaves close to the ground, clustered at the base of a flower-stalk.

RADICLE, the young root of the embryo.

RAMENTA, little brown withered scales with which the stems of some plants are covered.

RAMIFICATIONS, subdivisions of roots or branches.

RAPHE, the line which connects the

hilum and the chalaza in anatropal ovules.

RAPHIDES, crystals found in cells, which are hence called *Raphidian*.

RECEPTACLE, the flattened end of the peduncle rachis, bearing numerous flowers in a head; applied also generally to the extremity of the peduncle or pedicel.

RECLINATE, curved downward from the horizontal, bent back up.

RECURVED, bent backward.

REDUPPLICATE, edges of the petals or sepals turned outward in aestivation.

REGMA, seed-vessels composed of elastic cocci, as in *Euphorbia*.

REGULAR, applied to an organ, the parts of which are of similar form and size.

RELIQUÆ, remains of withered leaves attached to the plant.

RENIFORM, in shape like a kidney.

REPAND, having a slightly undulated or sinuous margin.

REPLUM, a longitudinal division in a pod formed by the placenta, as in *Crucifera*.

RESUPINATE, inverted by a twisting of the stalk.

RETICULATE, netted, applied to leaves having a network of anastomosing veins.

RETINACULUM, the glandular viscid portion at the extremity of the caudicle in some Pollinia.

RETORSE, turned backward.

RETUSE, when the extremity is broad, blunt, and slightly depressed.

REVOLUTE, leaf with its edges rolled backward in veneration.

RHIZOME, a stem creeping horizontally, more or less covered by the soil, giving off buds above and roots below.

RHIZOTAXIS, the arrangement of the roots.

RHOMBOID, quadrangular form, not square with equal sides.

RIB, the projecting vein of a leaf.

RINGENT, a labiate flower in which the upper lip is much arched.

ROOT-STOCK, same as Rhizome.

ROSETTE, leaves disposed in close circles forming a cluster.

ROSTELLUM, a prolongation of the upper edge of the stigmas in orchids.

ROSTRATE, beaked.

ROTATE, a regular gamopetalous corolla, with a short tube, the limbs spreading out more or less at right angles.

RUBEFACIENT, that which reddens the surface.

RUDIMENTARY, an organ in an abortive state arrested in its development.

RUFIOUS, rust-red.

RUGOSE, wrinkled.

RUMINATE, applied to mottled albumen.

RUNCINATE, a pinnatifid leaf with a triangular termination, and sharp divisions pointing downward, as in dandelion.

RUNNERS, procumbent shoots which root at their extremity.

RUSTY, rust-colored,

S

SAGITTATE, like an arrow; a leaf having two prolonged sharp-pointed lobes projecting downward beyond the insertion of the petiole.

SAMARA, a winged dried fruit, as in the elm.

SAPONACEOUS, soap-like.

SARMENTOSE, yielding runners.

SARMENTUM, sometimes meaning the same as Flagellum, or runner; at other times applied to a twining stem which supports itself by means of others.

SCABROUS, rough, covered with very stiff short hair.

SCALARIFORM, vessels having bars like a ladder, seen in ferns.

SCALES, small processes resembling minute leaves.

SCANDENT, climbing by means of supports, as on a wall or rock.

SCAPE, a naked flower-stalk, bearing one or more flowers arising from a short axis, and usually with radical leaves at its base.

SCARIOUS, or SCARIOSE, having the consistence of a dry scale, membranous, dry, and shriveled.

SCION, the young twig used as a graft.

SCLEROGEN, the thickening matter of woody cells.

SCORPIOIDAL, like the tail of a scorpion; a peculiar twisted cymose inflorescence, as in *Boraginaceæ*.

SCURFY, applied to stems and leaves covered with loose scales.

SECUND, turned to one side.

SECUNDINE, the second coat of the ovule, within the primine.

SEGMENTS, divisions.

SEGREGATE, separated from each other.

SEMINAL, applied to the cotyledons, or seed-leaves.

SEPAL, one of the leaflets forming the calyx.

SEPTATE, divided by septa or partitions.

SEPTICIDAL, dehiscence of a seed-vessel through the septa or edges of the carpels.

SEPTIFRAGAL, dehiscence of a seed-vessel through the back of the loculements, the valves also separating from the septa.

SEPTUM, a division in an ovary formed by the sides of the carpels.

SERICIOUS, silky; covered with fine, close-pressed hairs.

SERRATE, having sharp processes arranged like the teeth of a saw; *Biserrate*, when these are alternately large and small, or where the teeth are themselves serrated.

SERRULATE, with very fine serratures.

SESSILE, without a stalk, as a leaf without a petiole.

SETA, a bristle or sharp hair; also applied to the gland-tipped hairs of *Rosaceæ* and *Hieracium*, and to the stalk bearing the theca of mosses.

SETACEOUS and **SETIFORM**, in the form of bristles.

SETIFORM, bristle-shaped.
SETOSE, covered with setæ and bristles.
SHEATH, the lower part of the leaf surrounding the stem.
SILICULA, a short pod with a double placenta and replum, as in some *Crucifera*.
SILIQUA, a long pod, similar in construction to the silicle.
SIMPLE, not branching, not divided into separate parts. Simple fruits are those formed by one flower.
SINUOUS, with a wavy or flexuous margin.
SINUS, the base or recesses formed by the lobes of leaves.
SLASHED, divided by deep and very acute incisions.
SOCIAL PLANTS, such as grow naturally in groups or masses.
SOREDIA, powdery cells on the surface of the thallus of some lichens.
SPADIX, a succulent spike bearing male and female flowers, as in *Arum*.
SPATHE, large membranous bract covering numerous flowers.
SPAWN, same as Mycelium.
SPECIFIC CHARACTER, the essential character of a species.
SPERMAGONE, a microscopic conceptacle in lichens, containing reproductive bodies called spermatia; also a conceptacle containing fructification in fungi.
SPERMATIA, motionless spermatozooids in the spermagones of lichens and fungi.
SPERMODERM, the general covering of the seed, sometimes applied to the episperm or outer covering.
SPHEROIDAL, nearly spherical.
SPIKE, inflorescence consisting of numerous flowers sessile on an axis.
SPINE, or **THORN**, an abortive branch with a hard, sharp point.
SPIRAL VESSELS, having a spiral fibre coiled up inside a tube.
SPONGIOLE, the cellular extremity of a young root.
SPORANGIUM, a case containing spores.
SPORE, a cellular germinating body in cryptogamic plants.
SPORIDIUM, a cellular germinating body in cryptogamia, containing two or more cells in its interior.
SPORULES, the small spores in cryptogamia.
SQUAMIFORM, like scales.
SQUAMOSE, covered with scales.
SQUARROSE, covered with processes spreading at right angles, or in a greater degree.
STAMEN, the male organ of the flower formed by a stalk or filament, and the anther containing pollen.
STAMINATE, applied to a male flower, or to plants bearing male flowers.
STAMINODIUM, an abortive stamen.
STANDARD, same as Vexillum.
STELLATE, like a star.
STERIGMATA, cells bearing naked spores; also cellular filaments bear-

ing spermata and stylospores in the spermogones and pycnides.
STERILE, male flowers not bearing fruit.
STICHIDIA, pod-like receptacles, containing spores.
STIGMA, the upper cellular secreting portion of the pistil uncovered with epidermis.
STIGMATIC, belonging to the stigma.
STIPE, the stalk of fern fronds; the stalk bearing the pileus in Agarics.
STIPEL, appendage at the base of a leaflet.
STIPITATE, supported on a stalk.
STIPULATE, furnished with stipules.
STIPULE, appendage at the base of leaves.
STOLON, a sucker at first aerial, and then rooting.
STOLONIFEROUS, having creeping runners, which root at the joints.
STOMATA, openings in the epidermis of plants, especially in the leaves.
STOOL, a plant from which layers are propagated by bending down the branches so as to root in the soil.
STRAP-SHAPED, same as Ligulate; linear, or about six times as long as broad.
STRIATE, marked by streaks or striæ.
STRIGOSE, covered with rough, strong, adpressed hairs.
STROBILUS, a cone, applied to the fruit of firs, as well as to that of the hop.
STROPHIOLE, a swelling on the surface of a seed.
STRUMA, a cellular swelling at the point where a leaflet joins the midrib; also a swelling below the sporangium of mosses.
STYLE, the stalk interposed between the ovary and the stigma.
STYLOPOD, an epigynous disk seen at the base of the styles of *Umbellifera*.
STYLOSPORE, a spore-like body, borne on a sterigma, or cellular stalk, in the pycnides of lichens.
SUBEROUS, having a corky texture.
SUBTERRANEAN, underground; same as Hypogæal.
SUBULATE shaped like a cobbler's awl.
SUCCULENT, soft and juicy.
SUFFRUTICOSE, having the characters of an under-shrub.
SULCATE, furrowed or grooved.
SUPERIOR, applied to the ovary when free, or not adherent to the calyx; to the calyx, when it is adherent to the ovary; to the part of a flower placed next the axis.
SUPERNATANT, floating on the surface.
SUPRA-DECOMPOUND, doubly compounded.
SUSPENDED, applied to an ovule which hangs from a point a little below the apex of the ovary.
SUSPENSOR, the cord which suspends the embryo, and is attached to the radicle in the young state.
SUTURAL, applied to that kind of de-

hiscence which takes place at the sutures of the fruit.

SUTURE, the part where separate organs unite, or where the edges of a folded organ adhere; the ventral suture of the ovary is that next the centre of the flower; the dorsal suture corresponds with the midrib.

SYMMETRY, applied to the flower, has reference to the parts being of the same number, or multiples of each other.

SYNANTHEROUS, anthers united together.

SYNCARPOUS, carpels united so as to form one ovary or pistil.

SYNGENESIOUS, same as Synantherous.

T

TAP-ROOT, root descending deeply in a tapering, undivided manner.

TEGMEN, the second covering of the seed; called also Endopleura.

TEGMENTA, scales protecting buds.

TENDRILS, curling, twining organs, with which plants grasp supports.

TERATOLOGY, study of monstrosities and morphological changes.

TERCINE, the third coat of the ovule, forming the covering of the central nucleus.

TERETE, nearly cylindrical.

TERMINAL, at the top or end.

TERNARY, parts arranged in threes.

TERNATE, compound leaves composed of three leaflets.

TESTA, the outer covering of the seed; some apply it to the coverings taken collectively.

TETRADYNAMOUS, four long stamens and two short, as in *Cruciferae*.

TETRAGONOUS, having four angles.

TETRAMEROUS; a flower is tetramerous when its envelopes are in fours.

TETRASPORE, a germinating body in Algae, composed of spore-like cells, but also applied to those of three cells.

THALAMIFLORAL, parts of the floral envelope inserted separately into the receptacle of the thalamus.

THALAMUS, the receptacle of the flower, or the part of the peduncle into which the floral organs are inserted.

THALLOGENS, or **THALLOPHYTES**, plants producing a thallus.

THALLUS, cellular expansion in lichens and other cryptogams, bearing the fructification.

THECA, sporangium or spore case, containing spores.

THROAT, the orifice of a gamopetalous corolla.

THYRSUS, a sort of panicle, in form like a bunch of grapes, the inflorescence being mixed.

TIGELLUS, the young embryonic axis.

TOMENTOSE, covered with cottony, entangled pubescence, called tomentum.

TOMENTUM, dense, close hair.

TOOTHED, dentated.

TORUS, another name for Thalamus; sometimes applied to a much-developed thalamus, as in *Nelumbium*.

TRANSPIRATION, the exhalation of fluids by leaves, etc.

TRIADELPHOUS, stamens united in three bundles by their filaments.

TRIANGULAR, having three angles, the faces being flat.

TRICHOTOMOUS, divided successively into three branches.

TRIFOLIATE, or **TRIFOLIOLATE**, same as Ternate. When the three leaves come off at one point the leaf is *ternately trifoliolate*; when there are a terminal stalked leaflet and two lateral ones, it is *pinnately trifoliolate*.

TRIGONOUS, having three angles, the faces being convex.

TRIMEROUS; a trimerous flower has its envelopes in three or multiples of three.

TRIPARTITE, deeply divided into three.

TRIPINNATE, a compound leaf three times divided in a pinnate manner.

TRIPINNATIFID, a pinnatifid leaf with the segments twice divided in a pinnatifid manner.

TRIQUETROUS, having three angles, the faces being concave.

TRITERNATE, three times divided in a ternate manner.

TRUNCATE, terminating abruptly, as if cut off at the end.

TRYMA, drupaceous fruit like the walnut.

TUBER, a thickened underground stem, as the potato.

TUBERCLE, the swollen root of some terrestrial orchids.

TUBERCULATE, covered with knobs or tubercles.

TUBEROUS, applied to roots in the form of tubercles.

TUBULAR, bell-shaped; applied to a campanulate corolla, which is somewhat tubular in its form.

TUMID, swelling.

TUNIC, a coat or envelope.

TUNICATE, applied to a bulb covered by thin external scales, as the onion.

TURBinate, in the form of a top.

TURGID, swollen.

TYPICAL, applied to a specimen which has eminently the characteristics of the species, or to a species or genus characteristic of an order.

U

UMBEL, inflorescence in which numerous stalked flowers arise from one point.

UMBELLULE, a small umbel, seen in the compound umbellate flowers of many *Umbelliferae*.

UMBILICATE, fixed to a stalk by a point in the centre.

UMBILICUS, the hilum or base of a seed.

UNARMED, without prickles or spines.

UNCINATE, provided with an uncus, or hooked process.

UNCTUOUS, oily.
 UNDULATE, waved.
 UNGUICULATE, furnished with a short unguis.
 UNGUIS, claw, the narrow part of a petal; such a petal is called *Unguiculate*.
 UNICELLULAR, composed of a single cell, as some Algæ.
 UNILATERAL, arranged on one side, or turned to one side.
 UNISEXUAL, of a single sex; applied to plants having separate male and female flowers.
 URGEOLATE, urn-shaped; applied to a gamopetalous globular corolla with a narrow opening.

V

VALVATE, opening by valves, like the parts of certain seed-vessels, which separate at the edges of the carpels.
 VALVATE *ÆSTIVATION* and *VERNATION*, when leaves in the flower-bud and leaf-bud are applied to each other by the margins only.
 VALVES, the portions which separate in some dehiscent capsules.
 VASCULAR TISSUE, composed of vessels.
 VEINS, fibro-vascular skeleton of leaves.
 VELUM, veil; the cellular covering of the gills of an Agaric in its early state.
 VENATION, the arrangement of the veins.
 VENTRAL, applied to the part of the carpel which is next the axis.
 VERNATION, the arrangement of the leaves in the bud.
 VERRUCOSE, covered with wart-like excrescences.
 VERSATILE, applied to an anther which is attached by one point of its back to the filament, and hence is very easily turned about.
 VERTEX, the uppermost point.
 VERTICAL, perpendicular.
 VERTICIL, a whorl; parts arranged opposite to each other at the same level, or, in other words, in a circle round an axis. The parts are said to be *Verticillate*.

VERTICILLASTER, a false whorl, formed of two nearly sessile cymes, placed in the axils of opposite leaves, as in dead nettles.
 VESICLE, another name for a cell or utricle.
 VEXILLARY, applied to æstivation when the vexillum is folded over the other parts of the flower.
 VEXILLUM, standard, the upper or posterior petal of a papilionaceous flower.
 VILLOUS, covered with long soft hairs, and having a wooly appearance.
 VIRESCENT, green.
 VIRGATE, long and straight, like a wand.
 VISCIOUS, or VISCID, clammy, like bird-lime.
 VITELLUS, the embryo-sac when persistent in the seed.
 VITTE, cells or clavate tubes containing oil in the pericarp of *Umbellifera*.
 VIVIPAROUS, plants producing leaf-buds instead of fruit.
 VOLUBILE, twining; a stem or tendril twining round other plants.
 VOLVA, wrapper; the organ which incloses the parts of fructification in some fungi in their young state.
 VULNERARY, having a healing power.

W

WATTLED, having processes like the wattles of a cock.
 WHORLED, same as Verticillate.
 WINGS, the two lateral petals of a papilionaceous flower, or the broad flat edge of any organ.

X

XANTHOPHYLL, yellow coloring matter in plants.

Z

ZONES, stripes or belts.
 ZOOSPORE, a moving spore provided with cilia, called also Zoosperm and Sporozoid.



